CHAPTER 12

DIRECT LINEAR MEASUREMENTS AND FIELD SURVEY SAFETY

This chapter covers the various duties, the techniques, and the skills a chaining crew member must learn thoroughly concerning chaining operations and some of the devices used in chaining itself. DIRECT LINEAR MEASUREMENTS, as used in this chapter, are methods used for measuring horizontal distances with a tape (or chain) and/or with electronic distance-measuring instruments presently available in the military.

As a crew member, you should be concerned not only about the task at hand but also about the potential hazards to which you may be exposed in the field. It is important, therefore, that you recognize the precautions and safety measures applicable to the survey field crew. In this chapter we shall discuss these precautions and safety measures and also additional duties normally performed by the crew.

DUTIES OF A CHAINING CREW MEMBER

During a typical chaining operation, it is possible that many and varied duties other than the actual chaining itself are to be undertaken as part of the whole process. To prepare the field chaining party for the task ahead, we shall present some of these duties, as applicable. In some cases, these duties can be modified or tailored, contingent upon the mission, terrain features, and other conditions that may affect the speed and accuracy of the operation.

GIVING HAND AND VOICE SIGNALS

During fieldwork, it is essential that you communicate with the other members of the survey party over considerable distances. Sometimes you may be close enough to use voice communication; more often, you will use hand signals. Avoid shouting; it is the sign of a beginner. Standard voice signals between chainmen must be used at all times to avoid misunderstanding. There are also several recommended hand signals, most of which are shown in figure 12-1. Those shown are recommended, but any set of signals mutually agreed upon and understood by all members of the party can also be used. It is important to face the person being signaled. Sometimes, if it is difficult for you to see the other person, it helps to hold white flagging in your hand when giving signals. When signals are given over snow-covered areas, red or orange flagging is more appropriate.

Explanations of the hand signals shown in figure 12-1 are as follows:

1. ALL RIGHT. The “all right” is given by the instrumentman when the alignment is OK for a plumb line, a range pole, a stake, a hub, or any other device used as a target, or when the instrumentman has finished all activities at your location.

It is given by waving both arms up and down while extending them out horizontally from the shoulders. If the instrumentman, in aligning a target, extends both arms out horizontally from the shoulders without waving them, the signal means that the target should be held steady while a quick check of its position is being made.

2. MOVE RIGHT OR LEFT. This signal is given by the instrumentman when lining in a target on a predetermined line. It is given by moving the appropriate hand outward from the shoulder. A slow motion of the hand means that you must move a long distance; a quick, short motion means that you must move a short distance.

3. GIVE ME A BACKSIGHT. This signal is given when the instrumentman wants a target held at a previously located point. It is given by extending one arm upward with the palm of the hand forward.

4. GIVE ME A LINE OR THIS ISA HUB. This signal, given by the rodman or the chainman, is intended to indicate a hub or to ask for a line on the point indicating the exact location.

It is given by holding a range pole horizontally overhead, then moving it to a vertical

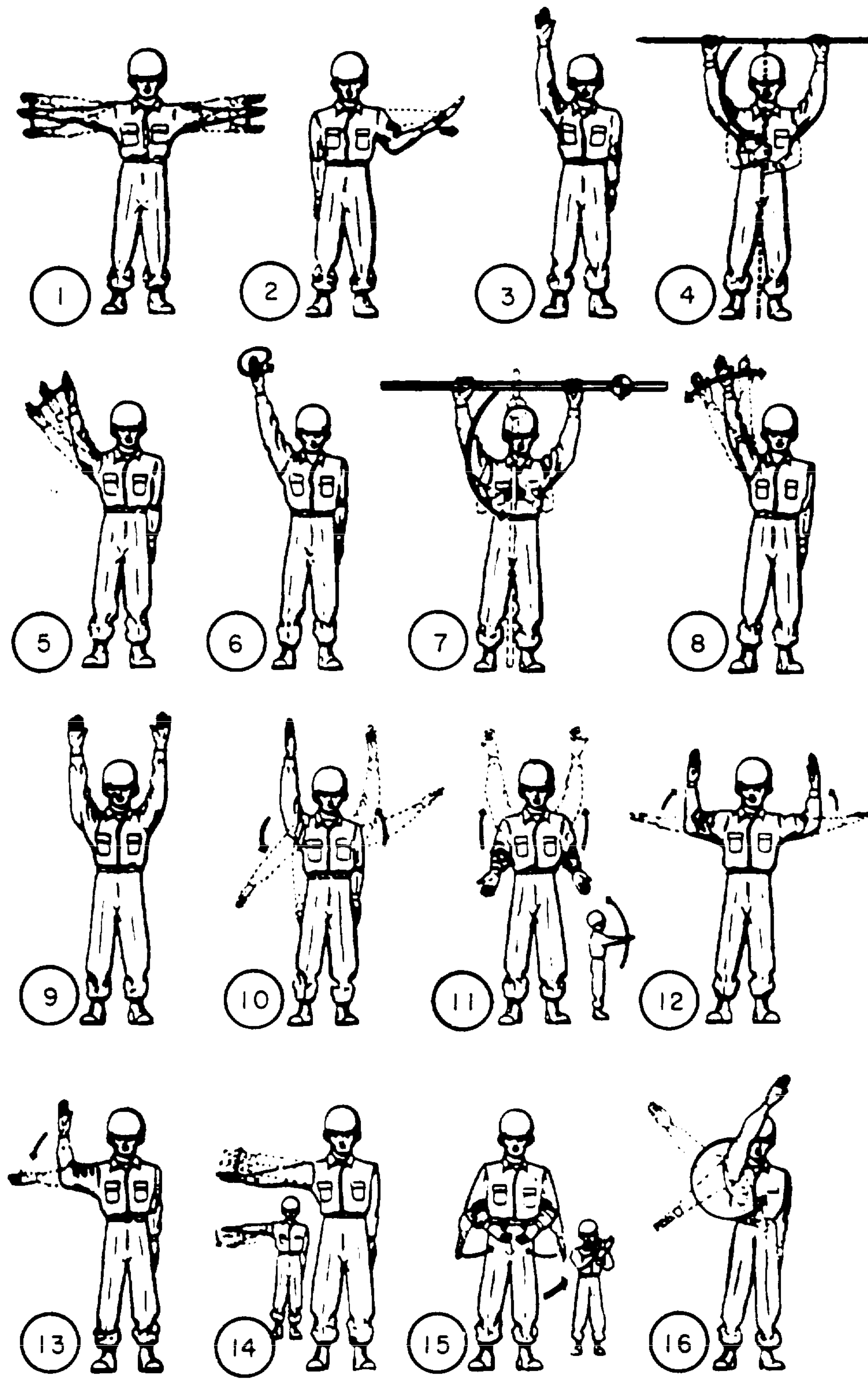

Figure 12-1.-Surveyor's hand signals.

position in front of the body. Sometimes the range pole tip is set on the ground to serve as a pivot. Then the pole may be swayed slowly to the left and/or right until the instrumentman picks up the signal.

5. PLUMB THE ROD. The signal to plumb the rod to the desired direction (right or left) is given by extending the appropriate arm upward and moving the hand in the direction the top of the rod must be moved to make it vertical.

6. ESTABLISH A TURNING POINT. This signal is given when the instrumentman wants a turning point established during traversing or leveling operations. It is given by extending either arm upward and making a circular motion.

7. THIS IS A TURNING POINT. The rodman gives this signal to indicate a turning point. This is done using a leveling rod and applying the method described in 4.

8. WAVE THE ROD. This signal, given by the instrumentman to the rodman, is important to get the lowest stadia reading. The instrumentman extends one arm upward, palm of the hand forward, and waves the arm slowly from side to side. The rodman then moves the top of the leveling rod forward and backward slowly about a foot each way from the vertical.

9. FACE THE ROD. To give this signal, the instrumentman extends both arms upward to indicate to the rodman that the leveling rod is facing in the wrong direction.

10. REVERSE THE ROD. The instrumentman gives this signal by holding one arm upward and the other downward, and then reversing their positions with full sidearm swings.

11. BOOST THE ROD. The instrumentman gives this signal by swinging both arms forward and upward, palms of the hands upward. This signal is used when the instrumentman wants the leveling rod raised and held with its bottom end at a specified distance, usually about 3 ft, above the ground.

12. MOVE FORWARD. The instrumentman gives this signal by extending both arms out horizontally from the shoulders, palms up, then swinging the forearms upward.

13. MOVE BACK. The instrumentman gives this signal by extending one arm out horizontally from the shoulder, hand and forearm extended vertically, and moving the hand and forearm outward until the whole arm is extended horizontally.

14. UP OR DOWN. The instrumentman gives this signal by extending one arm out horizontally from the shoulder and moving it upward or downward. This directs the rodman to slide the target up or down on the rod.

15. PICK UP THE INSTRUMENT. The party chief gives this signal by imitating the motions of picking up an instrument and putting in on the shoulder. The party chief or other responsible member of the party gives this signal, directing the instrumentman to move forward to the point that has just been established.

16. COME IN. The chief of party gives this signal at the end of the day's work and at other times, as necessary.

Two additional hand signals are shown in figure 12-2. Their meanings are given in the next two paragraphs.

RAISE FOR RED. The instrumentman gives this signal in a leveling operation to ascertain the immediate whole-foot mark after reading the tenths and hundredths of a foot. This usually happens when the rodman is near the instrument or if something is in the way and obscures the whole-foot mark.

EXTEND THE ROD. The instrumentman gives this signal when there is a need to extend an adjustable rod. This happens when the height of the instrument becomes greater than the standard length of the unextended adjustable level rod.

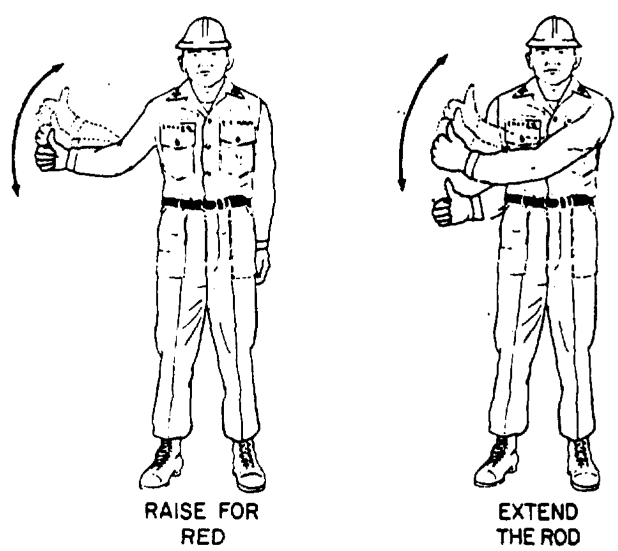

Figure 12-2.-Additional hand signals.

SIGNALS FOR NUMERALS. Figure 12-3 shows a simple system for numerals.

ONE—Right arm extended diagonally down to the right from the body

TWO—Right arm extended straight out from the body

THREE—Right arm extended diagonally up and out from the right shoulder

FOUR—Left arm extended diagonally up and out from the left shoulder

FIVE—Left arm extended straight out from the body

SIX—Left arm extended diagonally down to the left from the body

SEVEN—Both arms extended diagonally down and out from the body

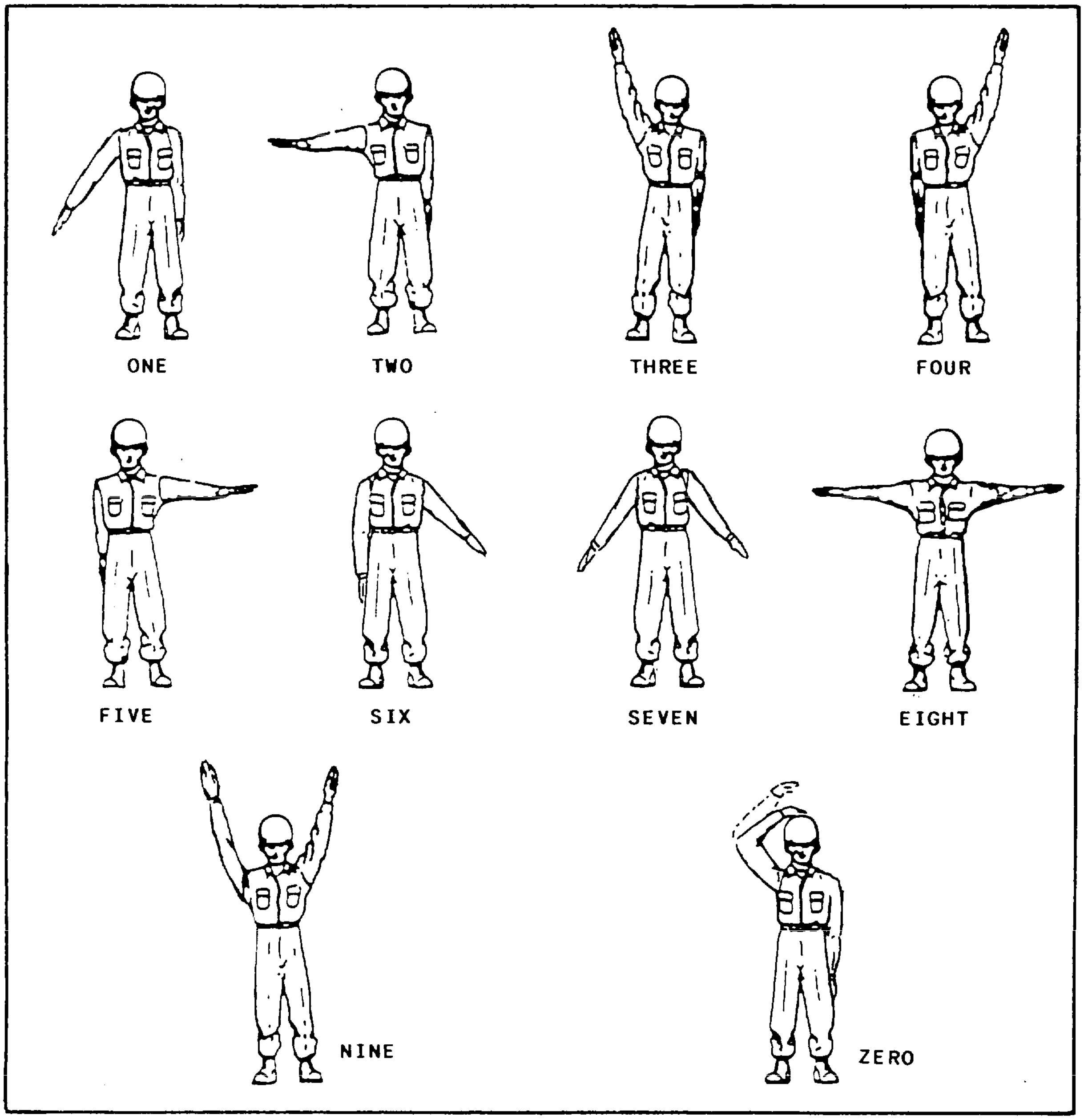

Figure 12-3.-Hand signals for numerals.

EIGHT—Both arms extended straight out from the body

NINE—Both arms extended diagonally up and out from the body

ZERO—Hitting the top of the head with an up-and-down motion of the palm

A decimal point should be indicated by using a signal that maybe easily distinguished from the other signals.

Make sure to orient yourself properly when receiving signals for Number 1 through Number 6; your left is the right of the signalman. The other numerals can be read without thinking of right or left. Use numeral signals only when necessary. Mistakes can easily result from misinterpreted signals.

It is important to remember that, if hand signals are used, they should be used consistently. It is important that every member of the survey party be completely familiar with them.

CLEARING THE LINE

A line must be cleared ahead when a crew is chaining (or taping) across brush-covered country. Specific tools, such as those presented in chapter 11, for the kind of job assigned must be used and handled with care. Before you start to swing, make sure that no one is within range.

You may cut ordinary scrub growth in unsettled areas more or less as needed. If, however, you encounter large trees or shrubs that may be of value, you should consult your party chief for advice. Even though a tree or shrub lies directly on the chaining line, it is never absolutely necessary that it be cut down. If it is desirable that it be preserved, you can always triangulate around it or bypass it by some other method, as described in a later chapter.

The principle technical problem in clearing the line is keeping on the line. When possible, this is accomplished by the use of natural foresights; that is, by the use of bearings taken on natural objects (or, perhaps, on artificial objects) lying ahead.

Suppose there is no distinctive object lying on the line of bearing ahead. In this case, you may be able to keep on the line by BLAZING ahead. To do this, you set up the compass and sight ahead on a tree lying as far ahead as possible. You then mark this tree by blazing. (A blaze is a scar notched on a tree with a hatchet or machete.) You could also use red or white flagging as markers. You then clear a line toward the tree.

Suppose the growth is too high and thick for you to sight ahead. In this case, you'll have to work ahead by looking back and aligning yourself on a couple of markers on the line already covered.

GIVING BACKSIGHTS AND FORESIGHTS

To run a line by instrument from a point of known location A to point B, for example, and given a distance and direction ahead, the instrumentman usually proceeds in the following manner:

1. Sets up the instrument (usually a transit) over point A.

2. Trains the telescope on the given direction of the line to B.

3. Sights through the telescope to keep the chainmen on line for as many consecutive foresights as can be observed from that particular instrument setup.

Suppose, for example, that the chainmen are using a 100-ft tape. After the instrument has been trained along the line of direction, the head chainman walks away with the zero-foot end of the tape, while the rear chainman holds the 100-ft end on the point plumbed by the instrument. After the head chainman has walked out the whole 100 ft, a plumb bob is dropped on a cord from the zero-foot mark to the ground.

The instrumentman sights along the line and thus determines the direction in which the head chainman must move to bring the plumb bob on to the line. The "move right" or "move left" signal is given, if needed. When the head chainman has been brought by signal to the vicinity of the line, the instrumentman signals for the final placement of the plumb bob by calling out, "To you!" (meaning "Move the plumb bob toward yourself!") or "Away!" (meaning "Move the plumb bob away from yourself!"). When the plumb bob is exactly on the line, the instrument man calls out, "Good!" or "All right!" The head chainman then marks the point indicated by the plumb bob in the correct manner. The first 100 ft have now been measured on the given line of direction.

If the distance to be measured is long, the chainmen will eventually proceed beyond the scope of the instrument as it is then set up. The instrument must then be shifted ahead to the last point marked by the head chainman. When the instrument has been set up over this point, the telescope must be reoriented to the line of direction. To do this, the instrumentman usually plunges the telescope (rotates it vertically) and backlights on a point on the line already laid off. In taking backlights, the instrumentman is guided by the rear chainman who holds on, or plumbs over, the point. When the telescope has been trained on the backsight point, it is again plunged. The telescope is now again trained in the desired direction.

Holding on a Point

If the point on the ground can be sighted through the telescope, the chainman may simply hold on the point; that is, hold a pencil point, chaining pin point, plumb bob point, or some other appropriate indicator on the point (fig. 12-4). Whatever the indicator may be, it is essential that it be held in an exactly vertical position. For short sights, it is also essential that the shaft of the indicator be relatively slender so that the vertical cross hair can be aligned with sufficient exactness.

Plumbing over a Point

If intervening low growth or some other circumstance makes it impossible for the instrumentman to sight the point on the ground, the chainman must plumb over the point, using the plumb bob and cord. If the distance is too far for observation of the plumb bob cord, the cord should be equipped with a plumb bob target, or a range pole may be used. In the absence of a target when using the plumb bob, you may tie a piece of colored flagging to the cord, or you may use a handkerchief, as shown in figure 12-5.

Some chainmen prefer to hold the plumb bob and cord with the cord running over the forefinger. Others prefer to have the cord running over the thumb. If you are plumbing high (that is, required to hold the cord at chest level or

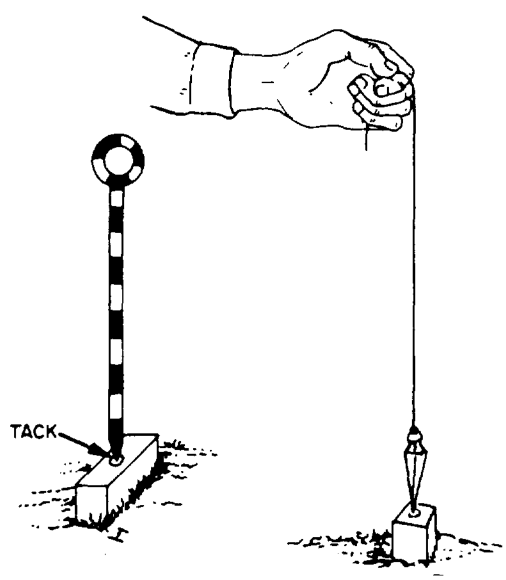

Figure 12-4.-Indicators used for short sights.

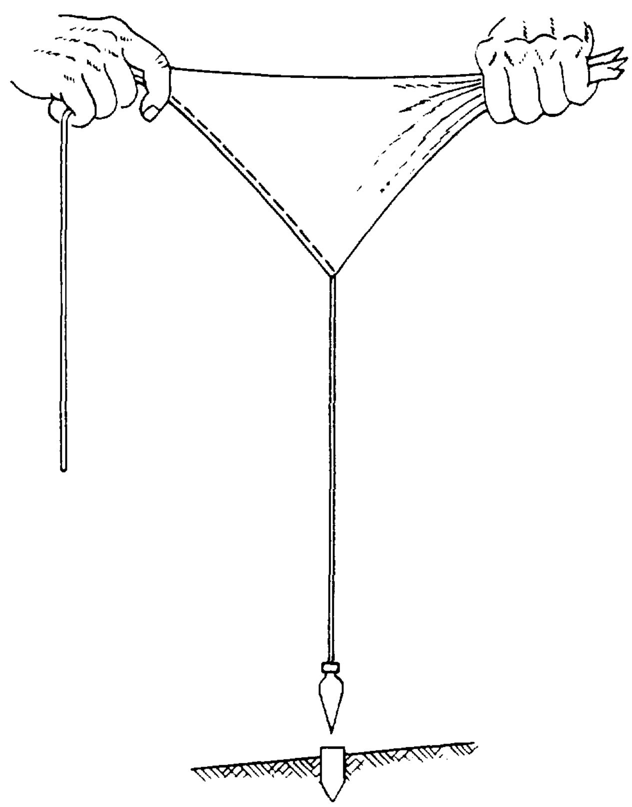

Figure 12-5.-Using a handkerchief as a substitute for a target on a plumb bob cord.

above), you need to learn to brace your holding arm with your other arm, and against your body or head or both, to avoid unsteadiness and fatigue. When there is a wind, you may find it difficult to hold the plumb bob suspended over a point. The plumb bob will tend to swing back and forth. You can overcome this problem by bouncing the point of the plumb bob slightly up and down on the point.

For a long sight, it is much better to plumb over a point with a range pole. For a short sight, however, the shaft of a range pole is too thick to permit exact alignment of the vertical cross hair.

For long sights, or for sights on a point that is to be sighted repeatedly, it is often desirable to construct a semipermanent target. There are no definite rules that can be stated for constructing targets because they usually must be built from materials at hand. Use your ingenuity; but make the target high enough to be seen, strong enough to withstand prevailing winds, and plumb over a point. Several types of semipermanent targets are shown in figure 12-6.

MARKING CONTROL POINTS, REFERENCE POINTS, AND MONUMENTS

In general, control surveys deal with established points. To define these points, surveyors

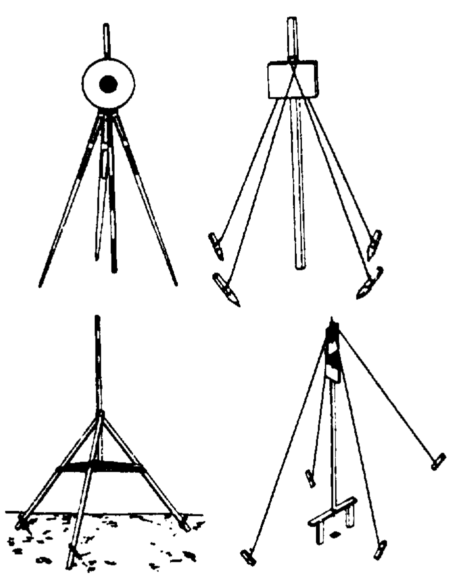

Figure 12-6.-Field-constructed semipermanent targets.

have to mark them. Certain points are made permanent; on the other hand, others are temporary. A line that will be used for a long period of time, for example, may be marked at each end with a bronze disk set in concrete, or with a center-punched metal rod driven flush with the ground. For less permanent control points, wooden stakes or hubs with nails, shiners, and flaggings can be used.

Placing Driven Markers

A DRIVEN MARKER must be set exactly vertically on the point it is supposed to mark. If it is driven on a slant, the top of the marker will not define the correct location of the point. To drive the marker vertically, first align it vertically; then, using a sledgehammer or other type of driving implement, strike each blow squarely on the flat end of the hub or stake.

A wooden hub is normally driven to mark the exact horizontal location of a point, usually for the purpose of plumbing an instrument over the point. Consequently, it is not normally necessary for the top of a hub (or other markers used for the same purpose) to extend much above the ground line. The precise location of the point is marked by a hub tack, punch mark, or other precise marker driven or set in the top of the hub. For work on asphalt roads or runways, you'll find it easier to use flagging or a soda pop top and a nail as a marker; in concrete and other hard surfaces, you can use orange paint or a star-drilled hole plugged with lead. The choice of markers to be used depends on the surveyor's judgment as well as the purpose of the survey.

In frozen or otherwise extra hard ground, use a bull-point to start a hole for a stake or hub. Remember that the stake or hub will follow the line of the opening made by the bull-point. Therefore, if the bull-point is not driven vertically, the stake or hub will not be vertical either.

Placing Monuments

In surveying, a MONUMENT is a permanent object or structure used where a point or station must be retained indefinitely for future reference. It may simply consist of a conspicuous point carved on an outcrop of a ledge rock or otherwise constructed in concrete. Figure 12-7 shows common types of concrete monuments. The top of the monument should have an area large enough to include the required point and any necessary reference data. The depth of the monument should be sufficient to extend below the frost line. If the depth of the frost line is unknown, a minimum depth of 3 ft is generally accepted. Other factors, such as soil condition and stability of foundation, may also affect the depth of the monuments. The area should be checked out for soil stability to provide an adequate foundation. A monument settles in the same manner as any other structure if an adequate foundation is not provided.

The exact location of the point on a monument may be marked by chiseling an X on the surface or by drilling a hole with a star drill and hammering in a lead filler or grouting in a length of brass stock (often called a COPPER). When grouting a copper, you should use neat cement grout because a fluid grout would flow into and fill the small space around the copper. If the point can be placed at the same time as the monument is being cast in place, the copper can be pushed down into the surface of the monument before the concrete begins to harden. If you are near an armory, you may be able to obtain large, expended brass shell casings. The primer end of a shell casing makes an excellent survey point marker when it is embedded in a concrete monument.

With a little imagination and ingenuity, you can easily design and construct adequate survey monuments when they are required.

Identifying Points

A point is marked with the information required to identify the point and with any other relevant data. Temporary identification marks can be made with keel. More permanent marks can be made with paint. An even more permanent mark consists of a metal plate set in concrete.

A. point that indicates a traverse station is marked with the symbol or number of the station, such as STA. B or STA. 21. A point on a stationed traverse is marked with the particular station, such as 2 + 87.08. Frequently, a point will serve as a traverse station and a bench mark. A bench mark is marked with an identifying symbol and usually with the elevation. In marking such an elevation, do not use a decimal point, as in 317.22 ft. Instead, raise the figures that indicate the fractional part and underline them; for example, $317^{\underline{22}}$ ft.

Referencing Points

All control points should be tied in or referenced. The ties or reference points are

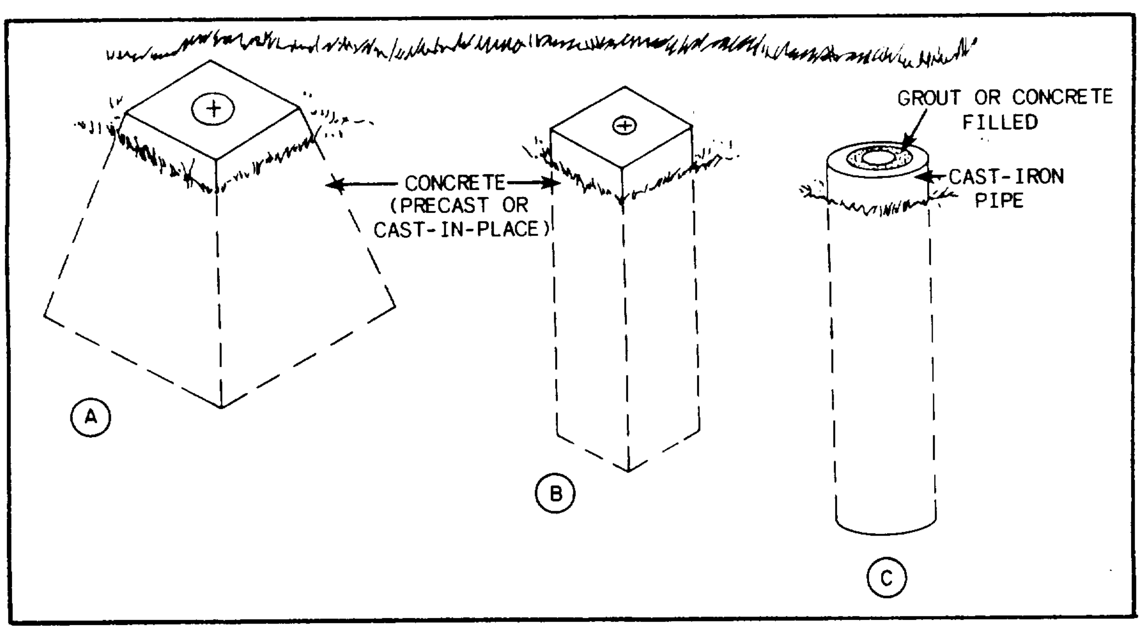

Figure 12-7.-Common types of survey monuments.

recorded in the field book as they are established in the field. The record may be done either by sketch, by work description, or by the combination of the sketch and notes. The control point must be referenced to some permanent type of object in its vicinity; if no such objects exist, REFERENCE HUBS are driven at points where they are unlikely to be disturbed. These ties are important in recovering control points that have been covered or otherwise hidden or in reestablishing them accurately if they have been removed.

The reference location of a particular point is recorded on the remarks page of the field book by sketches like those shown in figures 12-8 and 12-9. For a permanent control point, such as a triangulation point, monument, or bench mark, a complete "Station Description" is individually prepared for each station. The field offices of the National Oceanic and Atmospheric Administration or the National Geological Survey have these station descriptions on separate cards. This is done so they can easily run a copy for anyone requesting a description of a particular station. They also maintain a vicinity map on which these

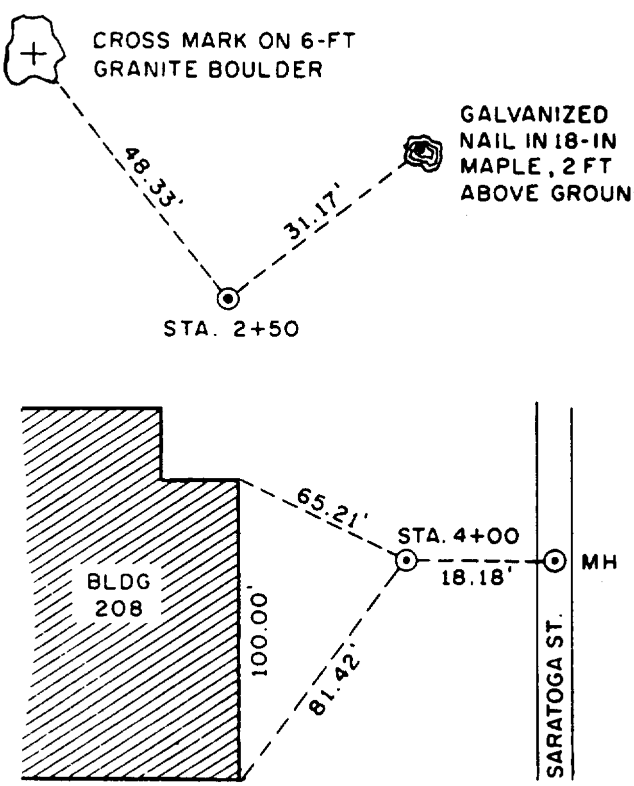

Figure 12-8.-Natural objects or man-made structures used as reference points.

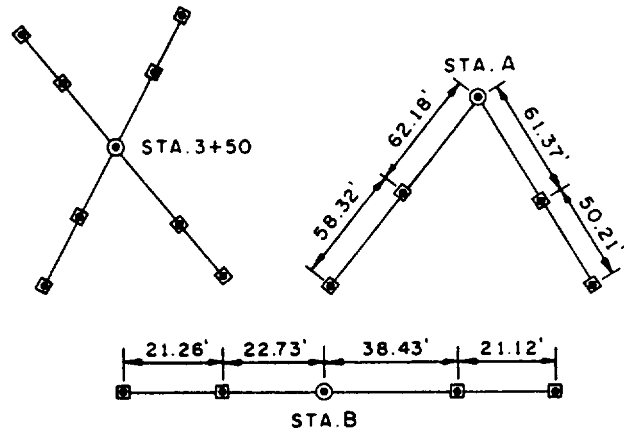

Figure 12-9.-Accurate methods for tying points.

points are plotted, and these station descriptions are used in conjunction with this map. The Navy's public works offices also maintain descriptions of stations within their naval reservation and its vicinity for immediate reference.

The methods of referencing points shown in figure 12-8 are ideal for recovering points that have been covered or otherwise hidden, and those shown in figure 12-9 are for reestablishment of these points accurately. The methods shown in figure 12-9 are generally used in construction surveys.

As you gain more experience, you may be assigned the task of writing a station description. In doing this, be sure to describe the location in detail, and make a sketch showing the location, ties, and magnetic or true meridian. Make your description concise and clear; and be sure to test its effectiveness by letting another EA (preferably not a member of the survey party that established the point) interpret your description. From the feedback of the interpretation, you can determine the accuracy of your written description. Your description, for example, should be written as follows (refer to figure 12-8): "Point A—plugged G.I. pipe 65.21 ft SE of NE corner of PWC Admin. Bldg. (Bldg. 208) and 81.42 ft from the SE corner of same building. It is 18.18 ft W of the center of a circular manhole cover located in Saratoga Street."

Protecting Markers

Markers are to be protected against physical disturbance by the erection of a temporary fence (or barricade) around them. Sometimes guard stakes embellished with colored flaggings are simply driven near the hub or similar marker to serve as deterrence against machinery or heavy equipment traffic. On the other hand, permanent markers are protected by fixed barricades, such as steel or concrete casing.

METHODS OF DIRECT LINEAR MEASUREMENTS

One of the most fundamental surveying operations is the measurement of horizontal distance between two points on the surface of the earth. Generally, there are two basic methods used: direct and indirect. Direct linear measurements, as explained earlier in this chapter, are methods used for determining horizontal distances with a tape (or chain) and/or with an electronic distance-measuring instrument. In indirect methods, the transit and stadia or theodolite and stadia are used. This section will discuss the common methods used in direct linear measurements.

CHAINING (OR TAPING)

The most common method used in determining or laying off linear measurements for construction surveys, triangulation base lines, and traverse distances is often referred to as CHAINING. The name is carried over from the early days when the Gunter's chain and the engineer's chain were in use. Today, it is more appropriate to call this operation TAPING because the steel tape has replaced the chain as the surveyor's measuring device. In this manual, however, chaining and taping are used interchangeably.

Identifying Duties of Chaining Party Members

Obviously, the smallest chaining party could consist of only two people—one at each end of the tape. To lay off a line to a desired distance, one person holds the zero end of the tape and advances in the direction of the distant point, while the other holds a whole number of the tape at the starting point. The person ahead, holding the zero end, is called the HEAD CHAINMAN; the other person is known as the REAR CHAINMAN.

In ordinary chaining operations, if the distance being measured is greater than a tape length, it is necessary to mark the terminal point with a range pole. In this way, the rear chainman can keep the head chainman aligned at all times whenever a full tape length or a portion of it is transferred to the ground.

The head chainman also acts as the recorder, and the rear chainman is responsible for keeping the tape in alignment. If more speed or precision in taping is required, additional personnel are assigned to the party. This relieves the chainmen of some of their duties and permits them to concentrate primarily on the measurement.

For more precise chaining, a three-man party is essential. In addition to the head and rear chainmen, a stretcherman is added. The duties of the stretcherman are to apply and to maintain the correct tension on the tape while the chainmen do the measuring. The head chainman still acts as the recorder and also reads and records the temperature of the tape.

Either of the two chaining parties described may have additional personnel assigned as follows:

- A recorder keeps a complete record of all measurements made by the taping party, makes any sketches necessary, writes descriptions of stations and reference points, and records any other data required. The head chainman or the chief of the chaining party may perform these duties.

- A rodman sets a range pole at the forward station to define the line to be taped, drives stakes to mark stations and reference points, carries the taping stool (discussed later) to the forward point, and performs other duties as directed.

- One or more axmen clear lines of sight between stations, cut and drive stakes, and perform other duties as directed.

- The chief of the chaining party directs the work of making the tape measurements, the establishment of stations, and other activities of the party in the field. The head chainman performs these duties when there is no separate party chief.

Coiling and Throwing a Steel Tape

Tapes generally come equipped with a reel; however, it is not always necessary to replace a steel tape on the reel at the end of each work period. A tape can be easily coiled and thrown into a circular roll.

Grasp the 100-ft graduation on the tape faceup with your left hand. Using your right hand, you take in 5 ft of tape at a time. Place the 95-ft mark over the 100-ft mark, next the 90-ft mark over the 95-ft mark—holding these 5-ft marks firmly with the left hand so that the tape will not turn over. Continue this operation for the entire length of the tape, placing each 5-ft division over the preceding one until the zero graduation is reached, (Actually, you can start at either end of the tape, whichever is convenient.) As you are taking in the tape, you will notice that the coils fall into the shape of the figure "8." (See fig. 12-10.)

When you have completed this coiling, square up the tape ribbons. The leather thong at the 100-ft end should be on the underneath side of the coil next to your hand. Wrap the thong around the complete coil. Continue wrapping until there is just enough of the thong left to conveniently insert it through the coil at about the 50-ft graduation. Draw the thong firmly back against the completed windings of the thong.

You can throw the tape into a more compact circular roll by giving the "8" a twist, as shown in figure 12-11. Now, tie the tape with the remaining thong.

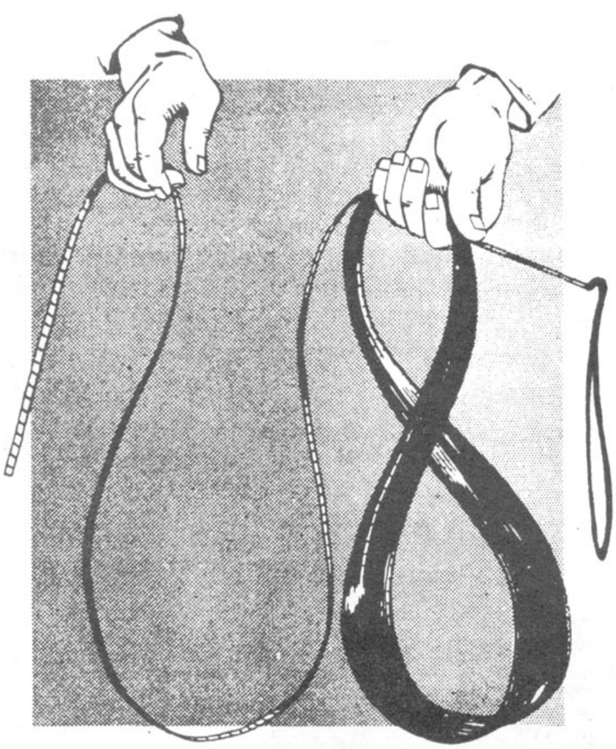

Figure 12-10.-Coiling a tape into a figure "8" form.

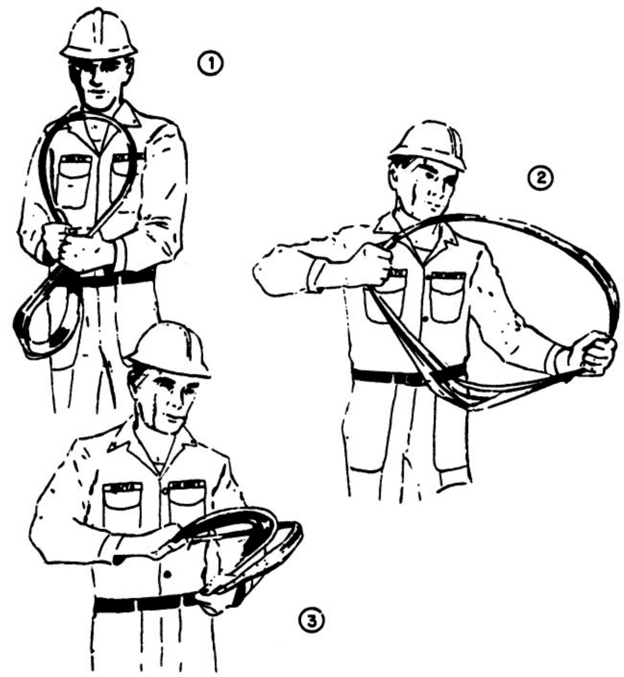

Figure 12-11.-Throwing the tape into a circular roll.

When you wish to use the tape again, reverse the process. Be sure you let the tape out from the zero end in the same way that it was wound. Walk away from the end of the tape as you unwind it to prevent kinks.

Chaining on Level Ground

When taping distances on a relatively level surface and of the third or lower order accuracy, you may lay the tape on smooth ground or on a paved road or support its ends by taping stools or stakes. In horizontal chaining, the tape is held horizontally, and the positions of the pertinent graduations are projected to the ground by a plumb bob and cord. For ordinary chaining on level ground, the following procedures are generally used:

1. A range pole is set on line slightly behind the point toward which the taping will proceed. The rear chainman, with one chaining pin, stations himself at the starting point of the line to be measured.

2. The head chainman, holding the zero end of the tape and with 10 pins in his hand, then moves forward toward the distant point while guiding himself with the range pole. Assuming that the tape was already off the reel when they

started, the rear chainman watches the tai1 end (100-ft mark) of the tape as the head chainman moves forward.

3. When the rear chainman sees that the tail end is about to reach his position, he calls "Chain!" At that time, the head chainman stops and looks back. The rear chainman holds the 100-ft mark at the starting point and checks the alignment; then signals the way the head chainman should move the chaining pin to be in line. While doing this, they are both in a kneeling position, the rear chainman facing the distant point, and the head chainman to one side facing the line so that the rear chainman has a clear view of the range pole. The head chainman, while stretching the tape with one hand, sets the pin vertically on line a short distance past the zero mark with the other hand. Then by pulling the tape taut and making sure that the tape is straight, the head chainman brings it in contact with the pin, The rear chainman, watching carefully for the 100-ft mark to be exactly on the point, calls "All right!" The head chainman relocates the pin to exactly the zero mark of the tape and places it sloping away from the line. He then pulls on the tape again to make sure that the zero mark really matches the point where the pin is stuck in the ground. Then, he calls "All right!" or "Stuck!" This is a signal to the rear chainman to release the tape so he can continue forward for the next measurement. The process is repeated until the entire distance is measured.

4. As the rear chainman moves forward, he pulls the pin from his point. Thus, there is always one pin stuck in the ground; therefore, the number of pins in his possession at any time indicates the number of 100-ft (stations) tape lengths they have measured from the starting point to the pin in the ground.

Every time the head chainman runs out of pins, he signals the rear chainman to come forward, and both of them count the pins in the rear chainman's possession. There should be 10 pins.

SUPPORTING THE TAPE.— When a full tape length is being measured, the two chainmen support the ends of the tape. The tape maybe laid on a level ground surface, such as a paved road or railroad rail, or suspended between stools or bucks set under the ends of the tape. For precise measurement, such as base line measurement, the tape is supported at midpoint or even at quarter points by bucks or stakes.

In horizontal taping over sloping or irregular terrain, one end of the tape is held on the point at ground level, while the other end is supported high enough to make the tape horizontal. As shown in figure 12-12, the rear chainman is holding a full graduation of the tape at the point near the ground, and the head chainman, holding the zero end, projects the desired distance to the point on the ground by using the plumb bob.

ALIGNING THE TAPE.— Any misalignment of the tape, either horizontally or vertically, will result in an error in the measurement. Misalignment always results in a recorded distance that is too great, or a laid offline that is too short. This is obvious, since the shortest distance between two points is a straight line. Keep the tape straight and level at all times.

APPLYING TENSION.— A tape supported or held only at the ends will hang in the shape of a curve, called a catenary, because of its own weight. Depending on the tension or pull applied at the ends, this catenary will become shallower or deeper; and the distance between the supported ends will vary considerably. To standardize this distance, you should apply a recommended "standard" tension when you are measuring. You should attach a spring balance or tension handle to one end of the tape and measure the correct standard tension. The amount of standard tension is discussed later under "Making Tape Corrections."

Maintaining a constant tension for any length of time by a hand pull is uncomfortable and can be erratic. For easier chaining, each chainman uses a pole or rod about 1/2 to 2 in. in diameter and about 6 ft long. The leather thong attached to the tension handle is wrapped around the pole at the proper height. The chainman braces the bottom end of the pole against the outside of his foot and applies tension by bracing his shoulder against the

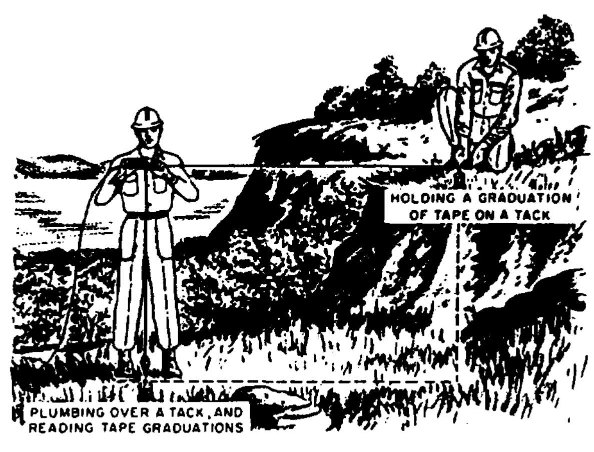

Figure 12-12.-Horizontal taping on a slope.

pole and shifting his body weight until the correct tension is read on the scale. This position can be held steadily and comfortably for a comparatively long time.

Measuring distances less than a full tape length requires the use of the clamp handle (or "scissors clamp"), which is attached to the tape at some convenient point along its length. The handle permits a firm hold on the tape and furnishes a convenient attachment for a spring balance. When properly used, the handle will prevent kinking of the tape.

READING THE TAPE.— A chain tape may be either a PLUS (or ADD) tape or a MINUS (or SUBTRACT) tape. On a plus tape, the end foot, graduated in subdivisions, is an extra foot, lying outside the 0-ft mark on the tape and graduated AWAY FROM the 0-ft mark. On a minus tape, the end foot, graduated in subdivisions, is the foot lying between the 0-ft mark and 1-ft mark and graduated AWAY FROM the 0-ft mark and TOWARD the 1-ft mark. As will be seen, this difference is significant when a distance of less than a full tape length is being measured.

Suppose that you are measuring the distance between point A and point B with a 100-ft tape, and the distance is less than 100 ft. Suppose that you are the head chainman. To start off, you and the rear chainman are both at point A. You walk away from point A with the zero-foot end of the tape. Because this is a plus tape, the tape has an extra foot beyond the zero-foot end, and this foot is subdivided in hundredths of a foot, reading from the zero.

You set the zero on point B, or plumb it over point B; then call out, "Take a foot!" When the rear chainman hears this, he pulls back the first even-foot graduation between A and B to point A, or plumbs it over point A. Let's say this is the 34-ft graduation, The rear chainman calls out, "Thirty-four!"

You now read the subdivided end-foot graduation that is on or over point B. Let's say it is the 0.82-ft graduation. You call out, "Point eight two!" The rear chainman rechecks the even-foot graduation on point A and calls out, "Thirty-four point eight two!" As you can see, your subdivided-foot reading is added to his even-foot reading; hence, the expression "plus" tape.

Suppose now that you are measuring the same distance between the same points, but using a "minus" tape; that is, a tape on which the subdivided end-foot lies between the zero-foot and 1-ft graduations. This time when you walk away with the zero-foot end, you set the 1-ft graduation on point B and call out, "Take a foot!" When he hears this, the rear chainman again hauls back the first even-foot graduation between A and B to point A—but this time this will be the 35-ft graduation. So the rear chainman sings out, "Thirty-five!" When you hear this, you read the subdivided-foot graduation on point B. This time this will be 0.18-ft graduation, so you call out, "Minus point one eight!" The rear chainman mentally subtracts 0.18-ft from 35.00 ft and calls out, "Thirty-four point eight two!" When you are also acting as the recorder, recheck the subtraction before you record the distance in the field notebook.

GIVING A LINE.— The range pole is set on line slightly behind the point toward which the taping will proceed. Line may be given (that is, the person with the range pole may be guided or signaled onto the line) by "eyeball" (that is, by eye-observation alignment by the rear chainman or someone else at the point from which chaining is proceeding) or by instrument.

Slope Chaining

The methods used in slope chaining are basically the same as in chaining on level ground. There are some differences, however, as follows: In slope chaining, the tape is held along the slope of the ground, the slope distance is measured, and the slope distance is converted, by computation, to horizontal distance. The slope angle is usually measured with an Abney hand level and clinometer; however, for precise measurement, it is measured with a transit.

In using the clinometer, you take the slope angle along a line parallel to the slope of the ground or along the tape that is held taut and parallel to the slope of the ground. To use the clinometer, you sight on an object that is usually a point on a pole approximately equal to your height of instrument (HI); that is, the vertical distance from the ground to the center (horizontal axis) of the sight tube. While sighting the object, you rotate the level tube about the axis of vertical arc until the cross hairs bisect the bubble as you look through the eyepiece. Then, you read either the slope angle or percentage on the vertical arc and record it along with the slope distance measurement. The horizontal distance is computed, or in other words, the tape correction is applied.

If the station points are being marked, the corrections to the slope distances are applied as the chaining progresses. These correct ions are computed either mentally, by calculator, or by using a table.

If the ground slope is fairly uniform, and if the tape corrections do not exceed 1 ft, a plus 100-ft tape is very useful to establish these station points. The head chainman determines the slope correction first, then lays off the true slope distance that gives a horizontal distance of 100 ft. If the slope is less than 2 percent, no slope correction is required. Slope corrections will be discussed later in this chapter.

Horizontal Chaining

In horizontal chaining, the tape is supported only at its ends and held in a horizontal position. Plumb bobs are used to project the end graduations of the tape (or, for a less-than-tape-length measurement, an end and an intermediate graduation) to the ground. Be very careful when you use the plumb bob both in exerting a steady pull on the tape and in determining when the tape is horizontal.

PLUMBING.— Plumbing is complete when the tape is in horizontal alignment and under the proper tension.

The rear chainman holds a plumb bob cord at the proper graduation of the tape, and the point of the plumb bob about one-eighth of an inch above the marker from which the measurement is being made. When the plumb bob is directly over the marker, he calls, "Mark!"

The head chainman holds a plumb bob cord at the correct graduation of the tape with the point of the plumb bob about 1 in. above the ground. He allows his plumb bob to come to rest; sees that the tape is horizontal; checks its alignment and tension; and when the rear chainman calls, "Mark!" allows the plumb bob to fall and stick in the ground. This spot is then marked with a chaining pin.

At times, in rough country, a small area around the point may require clearing for dropping the plumb bob. Because the clearing is usually done by kicking away small growth, this type of clearing is commonly called a KICKOUT. To determine the approximate location of the kickout, the head chainman may call, "Line for kickout!" and then "Distance for kickout!" At "Line for kickout!" the rear chainman or instrumentman gives the approximate line by eyeball. At "Distance for kickout!" the rear chainman holds approximately over the starting point without being too particular about plumbing.

LEVELING THE TAPE.— Figure 12-13 shows a pair of chainmen making a horizontal measurement on a slope. You can see that, to make the tape level, the person at the lower level is holding the end at chest level while the person at the higher level is holding it at knee level.

To maintain the tape in a horizontal position, the chainman at the lower level held the hand level. By studying the position of the other chainman, he decided that it would be possible to hold the tape at chest level. He then held the hand level at about the height of his own chest level and trained it on the other chainman. It indicated that a level line from his own chest level intersected the person of the other chainman at that person's knee level. So he called out, "At

Figure 12-13.-Horiziontal chaining using plumb bobs.

your knee!" thus informing the other chainman where to hold the end of the tape.

BREAKING TAPE.— The term *breaking tape* is used to describe the procedure for measuring directly horizontal distance on sloping ground, or through obstacles that do not permit the use of a full tape length. The procedure used in breaking tape is the same as ordinary chaining on level ground, except that the distances are measured by using portions of a tape, as shown in figure 12-14.

Generally, you will start breaking tape when the slope of the existing ground exceeds 5 percent (this depends also on the height of the chainmen). The reason for breaking tape is that the chainman on the lower ground will have difficulty in holding the tape steady and horizontal when his point of support exceeds his height. You also break tape to avoid hazardous measurements, such as crossing power lines and making measurements across a heavily traveled highway.

Now, to measure the distance AB shown in figure 12-14, the chainmen may proceed as follows: The rear chainman stations himself at point A. The head chainman pulls the tape forward a full tape length uphill toward point B and drops it approximately on line with the two range poles. He then comes back along the tape until he reaches a point at which a partial tape length, held level, is below the armpits of the rear chainman at point A. At this point, the head chainman selects a convenient whole-foot graduation, and the chainmen measure off the partial tape length (distance Aa) from starting point. As shown in the figure, the head chainman must be holding at the 60-ft mark to measure Aa. Then, he calls out, "Holding sixty!" so that the rear chainman knows what graduation he is holding when the measurement is made. As in other chaining methods, the rear chainman always checks the alignment.

After the pin is placed, the rear chainman (leaving the tape lying in position) moves forward to point a and gives a pin to the head chainman who, in turn, moves to point b; to make sure that the rear chainman takes the right graduation, he calls out, "Hold Sixty!" This procedure is repeated until a full station is measured or until a full-tape length measurement can be resumed. You see that to measure distance bc, both chainmen will probably use plumb bobs to transfer the distance to the ground.

Remember that the rear chainman gives the head chainman a pin only at each INTERMEDIATE point of a tape length. He keeps the pin at full tape lengths to keep track of the number of stations laid out as in ordinary horizontal chaining.

LAYING OFF A GIVEN DISTANCE.— Frequently, a chaining party is required to lay off a given distance and establish a new point on the ground. This is measuring by using a known distance on the tape and transferring it to the ground. If the distance is greater than a tape length, then the procedure described for measuring a full tape length is followed for the

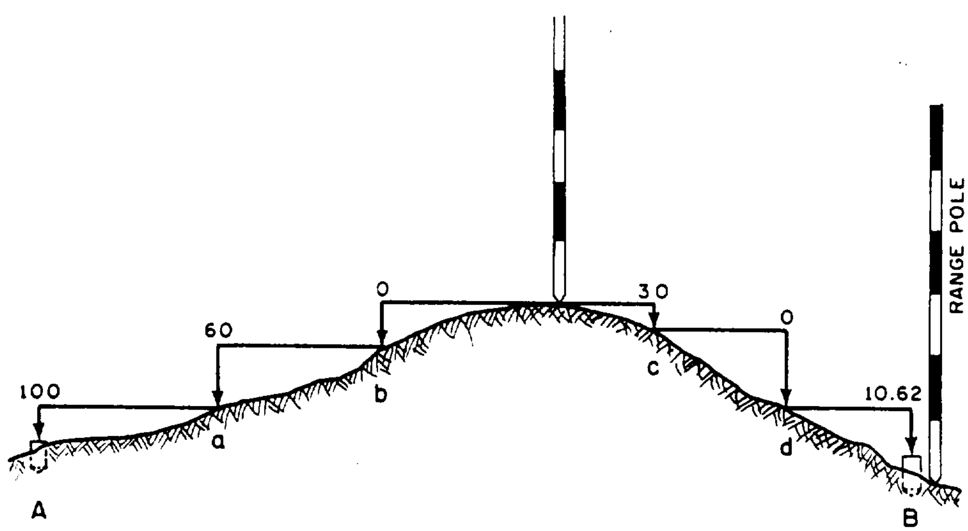

Figure 12-14.-Measuring horizontal distances by the "breaking tape" method.

required number of full tape lengths. The remaining partial tape length is then laid off by setting the rear chainman's plumb bob at the appropriate tape graduation.

Making Tape Corrections

A 100-ft tape should, in theory, indicate exactly 100.00 ft when it is in fact measuring 100.00 ft. However, a tape supported only at the ends has a sag in it, so when it indicates 100.00 ft, actually the distance measured is less. Even a tape supported throughout on a flat surface can be slightly longer under tension than it is without tension. Also, a tape will be longer when it is warm than when it is cold.

CALIBRATING A TAPE.— All tapes are graduated under controlled conditions of temperature and tension. When they are taken to the field, these conditions change. The tape, regardless of the material used to make it, will be either too short or too long. For low accuracy surveys, the amount of error is too small to be considered. As accuracy requirements increase, variations caused by the temperature and sag must be computed and used to correct the measured distance. In the higher orders of accuracy, the original graduation is checked for accuracy or calibrated at intervals against a standard distance. This standard is usually two points, a tape length apart, that have been set and marked using a more precise tape or a tape already checked. The standard may be just the precise or checked tape (known as the king or master tape). This tape is kept in a safe location and is not used for making field measurements, but only to check the accuracy of the field tapes. For the highest orders of accuracy, the tapes are sent to the National Bureau of Standards, U.S. Department of Commerce, Washington, DC, 20234, for standardization under exact conditions of tension, temperature, and points of support. A tape standardization certificate is issued for each tape, showing the amount of error under the different support conditions and the coefficient of expansion. The certificate (or a copy) is kept with each tape. For field operations, the tapes are combined in sets; one is selected as the king tape, while the others are used as field tapes.

The standard tension for a tape supported throughout is 10 lb, and the standard temperature is 68°F. Standard length is, simply, the nominal length of the tape. A 100-ft tape, for example, at a temperature of 68°F, supported throughout, and subject to a tension of 10 lb, should indicate 100 ft when it is measuring exactly 100 ft.

To CALIBRATE a 100-ft tape means to determine the exact distance it is actually measuring when it indicates 100 ft, while being supported throughout, at a temperature of 68°F and under a tension of 10 lb.

In addition to the National Bureau of Standards, many state and municipal authorities provide standardizing service.

RECOGNIZING TAPE OR STANDARD ERROR.— Suppose now that you send a 100-ft tape to the Bureau of Standards to be calibrated; the bureau will return a certificate with the tape. Assume that the certificate states that when the tape, supported throughout at a temperature of 68°F, and under a tension of 10 lb, indicates 100 ft, it actually measures 100.003 ft on the standard tape. The tape, then, has a STANDARD ERROR (also called TAPE ERROR) of 0.003 ft for every 100 ft it measures. This tape "reads short." Depending on the order of precision of the survey, you may have to apply this as a correction to measurements made with this particular tape.

CORRECTING FOR STANDARD ERROR.– Whether you add or subtract the standard error depends upon the direction of the error. The tape in the above example indicates a distance that is shorter than it actually measures; in other words, when you use this tape to lay off a distance of 100 ft, the line is actually 100.003 ft.

The decision to add or subtract the error depends upon whether you are measuring to determine the distance between two points or to set a point at a given distance from another.

Assume first that you're measuring the distance between two given points, and the distance as indicated by the tape is 362.73 ft. First, what is the total tape error? Obviously, it is 0.003 times the number of tape lengths. In this case, it is

$$0.003 \times 3.6273 = 0.0108819 \text{ ft},$$

which rounds off to 0.01 ft.

The next question is: Do you add this total correction to, or subtract it from, the recorded distance of 362.73 ft? Well, if you remember that the tape reads short, you will realize the reasonable thing to do is ADD the total standard error to the recorded distance. The correct distance between the two points, then, is 362.74 ft.

Suppose now that with the same tape, you are to set a point 362.73 ft away from another point.

Your correction here will be applied in the opposite direction. Since the tape reads short, the laid tape distance of 362.73 ft is LONGER than 362.73 ft by the amount of the total correction for standard error (0.01 ft). Therefore, you must SUBTRACT the total tape error. To lay off a distance of 362.73 ft with this tape, you would actually measure off a distance of 362.72 ft.

Suppose now that the Bureau of Standards calibration certificate states that when a tape indicates 100.00 ft under standard conditions, it is actually measuring only 99.997 ft. Again, the standard error is 0.003 ft per 100 ft, but this tape "reads long"; that is, the interval it indicates is LONGER than the interval it is actually measuring. Suppose you measure the distance between two given points with the tape and find that the tape indicates 362.73 ft. The total standard error is again 0.01 ft. Because the tape reads long, however, the distance it indicated was longer than the distance it actually measured. Therefore, the total standard error should be subtracted, and the distance between the given points should be finally recorded as 362.72 ft.

Suppose you are using this same tape to set a point 362.73 ft away from another point. Again, the total standard error is 0.01 ft. Because the tape reads long, however, a measurement of 362.73 ft by the tape will actually be LESS than 362.73 ft. Therefore, the total correction for standard error should be added, and you should measure off 362.74 ft by the tape.

CORRECTING FOR TEMPERATURE VARIATION.— Take again a 100-ft steel tape that has been calibrated at a standard temperature of 68°F. The coefficient of thermal expansion of steel is about 0.0000065 unit per 1°F. The steel tape becomes longer when its temperature is higher than the standard and shortens the same amount when it's colder. The general formula for variation in temperature correction is as follows:

$$C_t = 0.0000065L\ (T - To)$$

Where

C_t = Correction for expansion or contraction caused by variation in temperature

L = Tape calibrated length

To = Standard temperature (usually 68 °F)

T = Temperature during measurement.

From the above formula, you can deduce that the correction for a 100-ft tape is about 0.00065 ft per 1°F, which is about 0.01 ft for every 15°F change in temperature above or below the standard temperature of 68°F.

The temperature correction is applied in the same manner and direction as the standard tape error. If the tape measurement is taken at a higher temperature than standard, the tape will expand and will read short; naturally the correction should be added.

The error caused by variation in temperature is greatly reduced when an Invar tape is used.

CORRECTING FOR SAG.— Even under standard tension, a tape supported or held only at the ends will sag in the center, based on its weight per unit length. This sag will cause the recorded distance to be greater than the length being measured. When the tape is supported at its midpoint, the effect of sag in the two sections is considerably less than when the tape is supported only at its ends. As the number of equally spaced intermediate supports is increased, the distance between the end graduations will approach the length of the tape when supported throughout its length. The correction for the error caused by the sag between the two supports for any section can be determined by the following equation:

$$C_s = \frac{w^2 l^3}{24t^2}.$$

Where

C_s = correction for sag (in feet)

w = weight per unit length of the tape (in pounds per foot)

l = the length of the suspended section of tape (in feet)

t = tension applied to the tape (in pounds)

For full tape-length measurements, the correction for sag is usually taken care of by having the tape calibrated. The tape must be calibrated regardless of how it is supported and under standard temperatures and tension. To reduce the value of the horizontal correction for sag, the Bureau of Standards suggests standard tensions for tapes supported at only the ends as follows:

For 100-ft tapes, from 20 to 30 lb

For 150-ft tapes, from 25 to 30 lb

For 200-ft tapes, from 30 to 40 lb

Generally, for a heavy 100-ft tape weighing about 3 lb that was standardized, whether supported throughout or at the ends only, the systematic error per tape length caused by sag is as follows:

10-lb tension = 0.37 ft

20-lb tension = 0.09 ft

30-lb tension = 0.04 ft

For the Engineering Aid's survey work, measurements are normally in the lower order of precision. The correction for sag varies with the cube of the unsupported length; for short spans, it is often negligible.

CORRECTING FOR SLOPE.— When you take a measurement with a tape along an inclined plane (along the natural slope of the ground), obviously, the taped distance is greater than the horizontal distance. This taped distance is represented by s in figure 12-15.

The difference between the slope distance and the horizontal distance (s – d) is called the slope correction. This correction is always subtracted from the slope distance. To compute for the slope correction, you should know either the vertical angle, A, or the difference in elevation h between the taped stations.

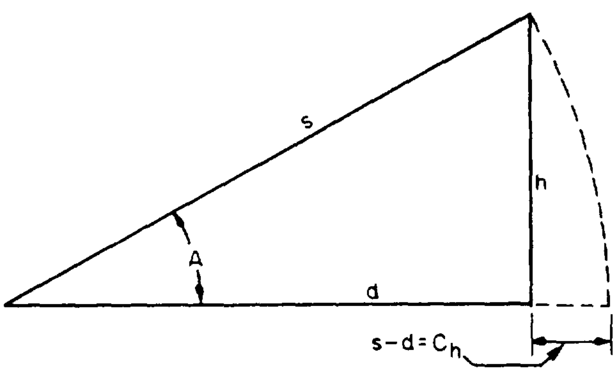

Figure 12-15.-Correction for slope distance.

When the vertical angle is used, the formula for slope correction is as follows:

$$C_h = s \text{ Vers } A.$$

Since

$$\text{Vers } A = (1 - \cos A),$$

then

$$C_h = s(1 - \cos A).$$

Where

C_h = the slope distance correction

s = the taped slope distance (usually a tape length)

A = the vertical angle

When the difference in elevation is used, the approximate formula derived by Pythagorean theorem of a right triangle (fig. 12-15) for the slope correction is as follows:

$$h^2 = s^2 - d^2$$

$$h^2 = (s + d)(s - d)$$

$$s - d = \frac{h^2}{s + d}.$$

But for a small slope, d is approximately equal to s; therefore,

$$s + d = 2s.$$

And since $C_h = s - d$ (from fig. 12-15), therefore,

$$C_h = \frac{h^2}{2s}.$$

For slopes greater than 5 percent, a closer approximation of C_h can be determined by expanding the above formula to this form.

$$C_h = \frac{h^2}{2s} + \frac{h^4}{8s^3}.$$

Preparing Chaining Notes

Before discussing the subject of chaining notes, we will mention a few general principles applicable to all types of field notes. It goes without saying that it is essential that measurements and other data be accurately recorded and that any additional information required to identify and clarify the data be included.

Field notes are required to be legible as well as accurate. If you don't write or print legibly, you will have to improve your script. All notes should be recorded in pencil; a 3H or 4H pencil is best for the job. A pencil that is too soft blunts too quickly; one that is too hard makes a faint mark and scores the paper. In the field, you need to carry a pocketknife or pocket pencil sharpener to keep your pencil sharpened or pointed.

There is a general rule to the effect that erasures are not permitted in field notes. Suppose that in the course of chaining several intervals you make a 10-ft "bust" in one of the intervals by misreading 10 ft as 20 ft. After you total up the distance, some circumstance leads you to suspect that the total is off. You recheck the work and discover where you made the bust. The notebook record for that interval must be changed. You make the change by crossing out the wrong entries and entering the correct ones above them—not by erasing the wrong entries.

RECORDING NOTES FOR HORIZONTAL CHAINING.— A typical example of a horizontal chaining conducted for a closed traverse is shown in figure 12-16. The chaining party started at station A and chained around by way of B, C, and so on. Arriving back at A, the party reversed its direction and chained back around by way of E, D, C, and so on, as a check. The distance finally recorded for each traverse line was the mean (average) between the forward measurement and the backward measurement.

Note on the bottom left-hand side the fact that the tape had a standard error of 0.013 ft per 100 ft of tape. The error is marked " + ," meaning that the amount of error should be added to the measurement as indicated by the tape. Obviously, the tape was reading short.

The corrections in the "Correction" column indicate that only correction for standard error

HORIZONTAL CHAINING
CLOSED TRAVERSE FROM △A to △A
NAVAUXAIRSTA FALLON, NEV.

STA	Length in Feet				
	Fwd	Bwd	Mean	Correction	Correct Length
A					
	242.47	242.40	242.43	+0.03	242.46
B					
	148.29	148.39	148.34	+0.02	148.36
C					
	199.72	199.68	199.70	+0.03	199.73
D					
	198.16	198.22	198.19	+0.02	198.21
E					
	153.62	153.54	153.58	+0.02	153.60
A					
	total perimeter length				942.36
Standard tape error +0.013					

100-ft Steel Tape #2 — Q. Smith, EA3; B. Yates, EACN; 25 Nov; Clear & mild

Tack in pine hub at SE corner Field
W to 10" oak tree
Nail in 10" oak tree
NW to 4' granite boulder
Cross on 4' granite boulder
NE to pine hub at N corner Field
Tack in pine hub at N corner Field
SE to Concrete monument
Brass rod on concrete monument
S to pine hub at A

Sketch

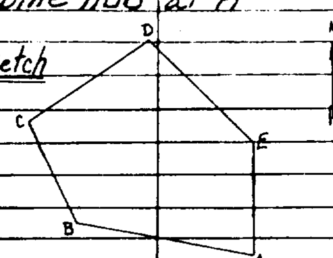

Figure 12-16.-Notes for horizontal chaining.

was made. If corrections for temperature and sag had been made as well, the algebraic sum of all three would have been entered in the correction column, or additional columns for temperature and sag correction would appear.

The symbol for each station is listed in the first column on the data page. Opposite, on the remarks page, a description of the station is recorded.

In the second and third columns on the data page, the measured forward and backward distances between adjacent stations are recorded. The average distance is recorded in the fourth column. In the fifth column, the standard error of 0.013 ft per 100 ft of tape is computed for each mean measurement. In the sixth column, the result of this error, added to the mean measurement, appears as the "Corrected Length." The sum of the corrected lengths appears below as "total length perimeter."

RECORDING NOTES FOR SLOPE CHAINING.— Figure 12-17 shows an example of slope chaining notes. Notice that on the data page, extra columns have been assigned for the temperature of the tape at each interval, the difference in elevation between supports, and the slope distance.

Under "Tape Corr." in the fifth column, the standard error for each interval is entered. Again, the tape had a standard error of 0.013 ft per 100 ft; therefore, the standard error for each interval except the last is 0.013 ft. For the last interval of 73.18 ft, the error works out as 0.009 ft.

If you will look to the right of the "Tape Corr." column, you will see the "Temp. Corr." column. For the first two intervals measured, the temperature of the tape was 78°F, or 10°F above standard. The correction amounts to 0.01 ft for each 15°F above standard; therefore, the total temperature correction for each of these intervals equals the value of x in the equation

$$\frac{0.01}{15} = \frac{x}{10}.$$

The total temperature correction is 0.007 ft. Because the temperature was above standard, the tape lengthened and was reading short. So the

SLOPE CHAINING
FROM △K to △L
NAVAUXAIR STA FALLON, NEV.

STA	°F	EL.	Slope Dist.	Tape Corr.	Temp Corr.	Slope Corr.	Total Corr.	Horiz. Dist.
K								
	78	6.0	100.00	+.013	+.007	-.180	-.160	99.84
	78	6.7	100.00	+.013	+.007	-.224	-.204	99.80
	79	7.1	100.00	+.013	+.007	-.252	-.232	99.77
	79	6.9	100.00	+.013	+.007	-.238	-.218	99.78
	79	6.8	100.00	+.013	+.007	-.231	-.211	99.79
	79	7.0	100.00	+.013	+.007	-.245	-.225	99.77
	80	6.9	100.00	+.013	+.008	-.238	-.217	99.78
	80	6.8	100.00	+.013	+.008	-.231	-.210	99.79
	80	4.7	73.18	+.009	+.006	-.151	-.136	73.04
L		Total △K to △L					=	871.35
Standard Tape error				±0.013				

100' Steel Tape #2	Q. Smith, EA3 B. Yates, EACN 2 APR
	Clear & Warm
Tack in pine hub	at NW corner Field
Tack in pine hub	30' SE of Tower

Figure 12-17.-Notes for slope chaining.

corrections should be added as indicated by the plus signs.

To the right of the "Temp. Corr." column is the "Slope Corr." column. Its entries are to be subtracted as indicated. Use the following equation to compute the slope correction.

$$C_h = \frac{h^2}{2s}.$$

For the first taped interval, we have an h of 6.0 ft and an s of 100 ft.

Therefore

$$h^2 = 6.0^2 = 36.0 \text{ ft and}$$

$$2s = 2 \times 100 = 200 \text{ ft.}$$

The slope correction is computed as follows:

$$\frac{36.00}{200.00} = 0.180 \text{ ft.}$$

Next to the column for slope correction comes the "Total Corr." column, containing the algebraic sum of the three corrections for each taped interval. Finally, in the "Horiz. Dist." column, each value is determined by subtracting the total correction for each interval from the measured slope distance for that interval. (This example used in figure 12-17 happens to be all negative.) At the bottom of this column, the sum of the horizontal distances appears. This is the horizontal distance from station K to station L.

Solving Surveying Problems by Tape

Before the modern instruments used to measure angles directly in the field were devised, the tape (or rather, its equivalent, the Gunter's chain) was often used. This tape was used not only for measuring linear distances but also for measuring angles more accurately than was possible with a compass.

LAYING OUT A RIGHT ANGLE.— In laying out a right angle (or erecting a perpendicular) by tape, you apply the basic trigonometric theory that a triangle with sides in the ratio of 3:4:5 is always a right triangle.

Assume that on the line AB shown in figure 12-18, you want to use a 100-ft tape to run a line from C perpendicular to AB. If a triangle with sides in the ratio of 3:4:5 is a right triangle, then one with sides in the ratio of 30:40:50 is also a right triangle. From C, measure off DC, 30 ft

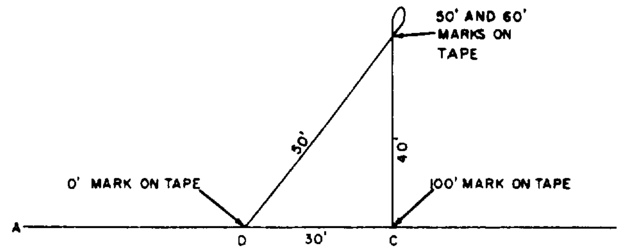

Figure 12-18.-Laying out a right angle using a 100-foot tape.

long. Set the zero-foot end of the tape on D and the 100-ft end on C. Have a person hold the 50-ft and 60-ft marks on the tape together and run out the bight. When the tape becomes taut, the 40-ft length from C will be perpendicular to AB.

MEASURING AN ANGLE BY TAPE.— There are two methods commonly used to determine the size of an angle by tape: the CHORD method and the TANGENT method.

The chord method can be applied, using the example shown in figure 12-19. Suppose you want to determine the size of angle A. Measure off equal distances from A (80.0 ft), and establish points B and C. Measure BC; assume that it measures 39.5 ft, as shown. You can now determine the size of angle A by applying the following equation:

$$1 - \cos A = \frac{2(s - b)(s - c)}{bc}$$

in which

$$s = 1/2(a + b + c) = 99.7 \text{ ft.}$$

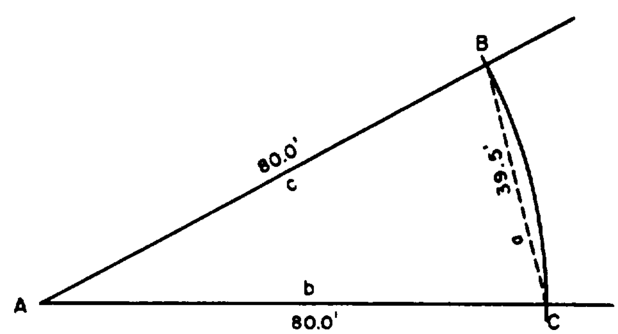

Figure 12-19.-Determining the size of an angle by the chord method.

First, solving for

$$1 - \cos A$$

we have

$$1 - \cos A = \frac{2(19.7)(19.7)}{6400} = \frac{776.2}{6400} = 0.12128.$$

Since

$$1 - \cos A = 0.12128$$

$$\cos A = 1.00000 - 0.12128 = 0.87872.$$

Reference to a table of natural functions shows that the angle with cos equal to 0.87872 measures, to the nearest 1 min., 28°29′.

The intervals measured off from A were made equal for mere convenience. The solution will work just as well for unequal intervals.

In determining the size of an angle by the tangent method, you simply lay off a right triangle and solve for angle A by the common tangent solution.

Suppose that in figure 12-20, you want to determine the size of angle A. Measure off AC a convenient length (say, 80.0 ft). Lay off CB perpendicular to AC and measure it; say it measures 54.5 ft, as shown. The angle is computed by using the following formula:

$$\tan A = \frac{54.5}{80.0} = 0.68125.$$

The angle with tangent 0.68125 measures 34°18′.

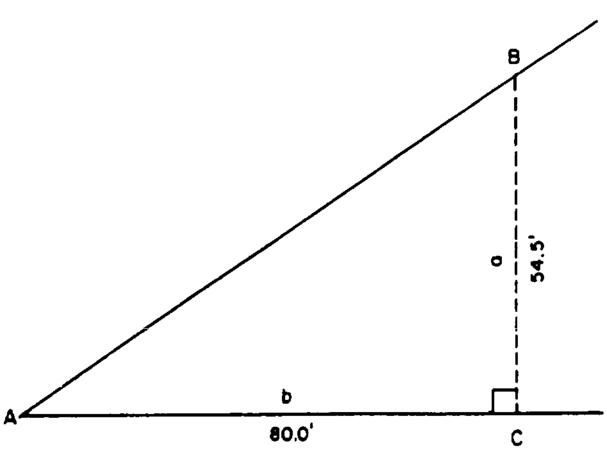

Figure 12-20.-Determining the size of an angle by the tangent method.

LAYING OFF AN ANGLE OF A GIVEN SIZE.— An angle of a given size can be laid off by tape by applying the tangent right triangle solution. Suppose that in figure 12-21, you want to lay off a line AC from A, 25° from line AB,

Again measure off a convenient 80.0 ft from A to establish point B. Erect a perpendicular from B as shown by the dotted line. You want to measure off along this perpendicular side a (opposite side), the distance that, when divided by the adjacent side, will give the value of the natural tangent of 25°. Use the following formula:

$$\tan 25° = \frac{a}{80.0}$$

$$a = 80.0 \tan 25°.$$

The tangent of 25° is 0.46631, so

$$a = 80.0 \times 0.46631 = 37.3 \text{ ft}.$$

Measure off 37.3 ft from B to establish point C. A line from A through C will form an angle of 25° from AB.

Identifying Chaining Mistakes and Errors

In surveying, distinctions are made between ERRORS and MISTAKES. Errors are caused by factors such as the effects of nature, the physical condition of the personnel performing the survey, and the condition of your instruments. Mistakes, however, are simply human blunders. While errors may be compensated for, mistakes can be detected, correct, and better yet, prevented only by the exercise of care.

COMMON MISTAKES.— Mistakes may result from poor work habits, lack of judgment, or confusion. They are often costly, time consuming, and difficult to detect. The easiest way to avoid them is to establish a definite procedure and follow it, being constantly alert during the

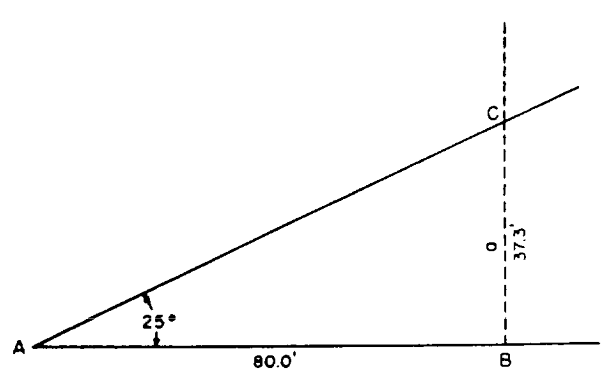

Figure 12-21.-Laying off an angle of a given size.

operations in which mistakes are possible. Some of the more common mistakes are as follows:

- Failing to hold graduations plumb over points

- Involuntarily transposing figures, such as recording 48.26 for 48.62

- Misreading figures that are viewed upside down, such as recording an upside-down 9 as a 6

- Reading a subdivided end-foot from the wrong end, as, for example, 0.28 ft instead of 0.22 ft

- Associating subdivided end-foot reading with wrong whole-foot mark, as 38.21 ft instead of 37.21 ft

- Subtracting incorrectly when using a minus tape

- Omitting an entire tape length

RECOGNIZING COMMON ERRORS.— There are two types of errors: accidental and systematic.

An accidental error is, generally speaking, one that may have a varying value. Examples are as follows: variation of the tension applied to the tape, inaccurate sticking of pins or other markings, and inaccurate determination of slope. Accidental errors can be minimized by carefulness, but not entirely eliminated.

A systematic error has a constant value. The standard error in a tape, for example, is a systematic error. Temperature and sag corrections are applied to correct systematic errors. Systematic errors can be compensated for or otherwise eliminated by the application of corrections.

Caring for and Maintaining a Survey Tape

If a steel or metallic tape gets a kink in it, it is then subjected to strain. The tape at best will be distorted at the point where the kink lies. At worst, if the strain is strong enough, the tape will break at the point where the kink lies. Kinks, therefore, are to be avoided at all costs; it is especially important to avoid putting a strain on a tape with a kink in it.

Under favorable circumstances, when a tape is shifted ahead, the head chainman may simply drag it over the ground. It is not a good idea for the rear chainman to assist by dragging that end because this develops a curve in the tape. This curve may snag on an obstruction and also may be the cause of a kink. When a tape is being dragged, the rear chainman should simply allow the end to trail along. The cardinal rule is “keep, the tape straight.”

When taping in traffic, you plan your moves in advance and make the measurement as fast as possible. If possible, do not let vehicles run over the tape; however, if this is absolutely unavoidable, be sure the tape is laid flat and taut on the road. NEVER let a vehicle run over a tape laid on a soft or rugged ground surface.

Tapes are made as corrosion-resistant as possible, but no steel tape is entirely immune to corrosion, especially when used around salty water. Therefore, a tape should always be wiped dry before it is put away, and it should be oiled periodically with a light, rust-resistant oil. If a tape does rust, rubbing it with light steel wool dipped in a rust-removing compound is the best and safest way to remove the rust. Tapes, especially those in reels, though not used during the week, should be removed from the reel and inspected each week for signs of corrosion. A damp climate in your area of operations could easily start corrosion in tapes.

Splicing a Tape

In spite of being carefully handled, tapes sometimes break. A broken tape is rejoined by splicing. A relatively light tape can be repaired with a punch-and-rivet tape splicer and repair stock (fig. 12-22). A repair stock consists of a

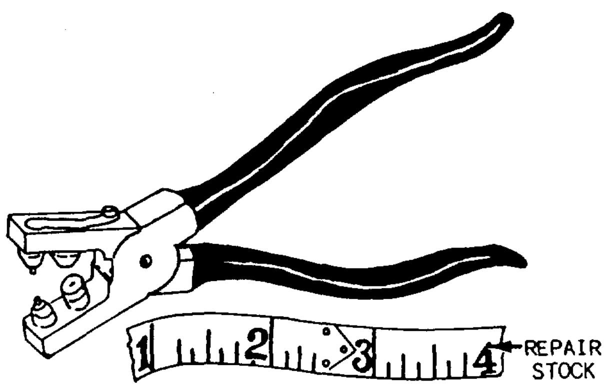

Figure 12-22.-A punch-and-rivet tape splicer with repair stock.

length of tape of the same thickness and width as that of the broken tape. When a tape is repaired, it is best to use a good section of the tape for calibration (matching a whole-foot mark). Place the section used for calibrating beside the broken section to make sure that you will maintain the original length of the tape after rejoining it.

In splicing a broken tape, first align and rivet the repair stock at one end of the break. Next, place the repair stock on the face of the other section of the tape by using the calibrating section as a measure for the break splice. Insert one rivet at a time and arrange rivets in a triangular pattern. Do not place rivets closer together than one-fourth in. from center to center. Now use a three-edge file. File partially through the surplus stock diagonally across the tape. The segment of the surplus will readily break off, leaving a clean splice.

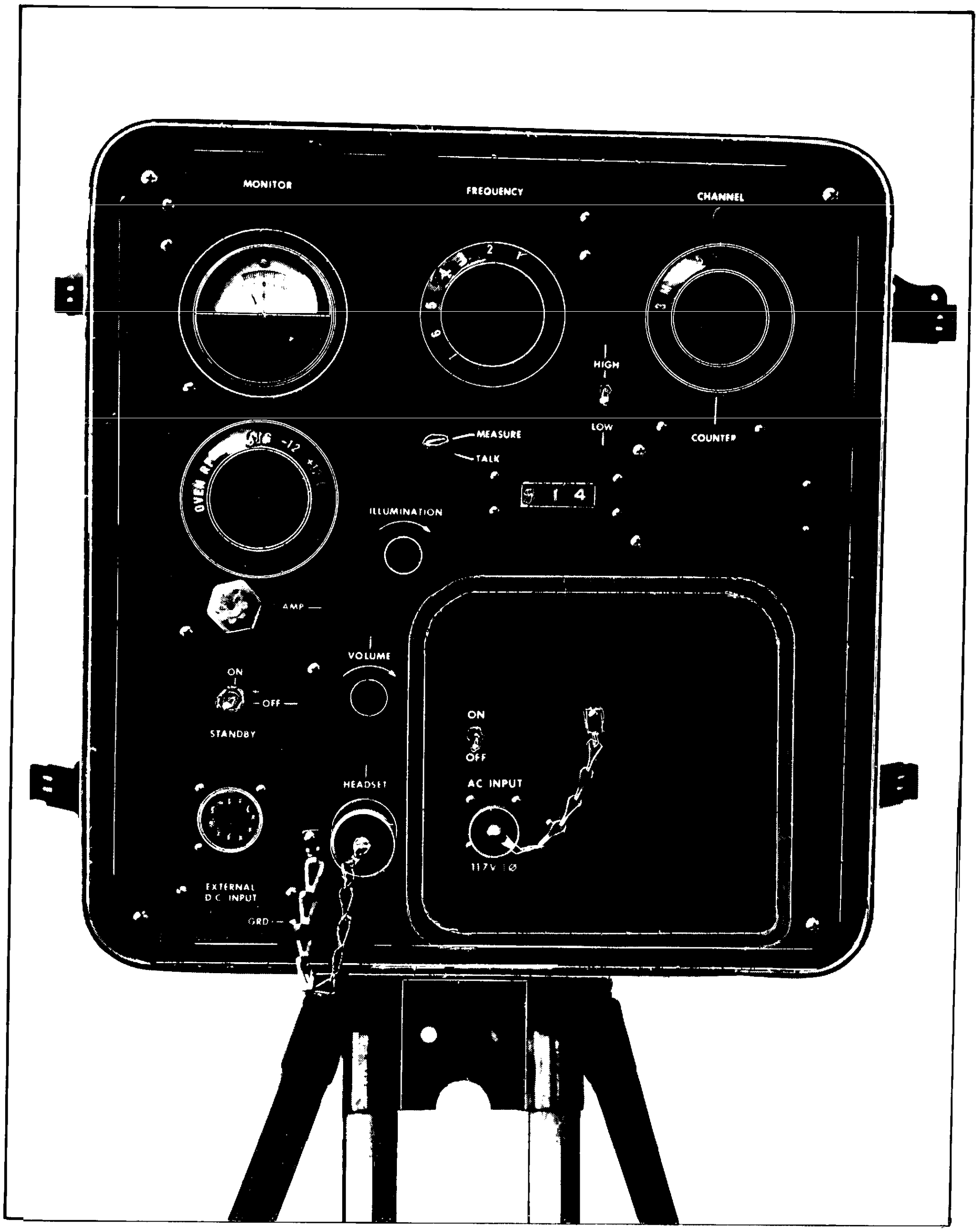

Figure 12-23.—A microwave distance-measuring device (Model 99).

Heavy steel tapes are repaired in a similar manner, using the tape repair kit shown in chapter 11, figure 11-55.

MEASURING BY THE ELECTRONIC DISTANCE-MEASURING SYSTEM

The electronic distance-measuring system is now incorporated in various present-day surveying practices, including traverse and triangulation network. In traverse measurements, accurate distances are directly measured in a straight line and with minimum instrument setups. In triangulation, the system is used to conduct base line measurements that are precise enough to maintain the accuracy of the survey.

In the electronic distance-measuring system, the length of a linear interval is determined by the use of equipment that (1) sends out an electronic impulse of some sort, such as a radar microwave or a modulated light wave, and (2) measures the time required for the impulse to travel the length of the interval. The velocity or rate of travel of the impulse is known. Therefore, once the time is also known, the length of the linear interval can be determined by applying the well-known equation "distance = rate x time."

Two types of electronic distance-measuring devices (also called EDMs) commonly used today are the MICROWAVE DEVICES and the LIGHT WAVE DEVICES.

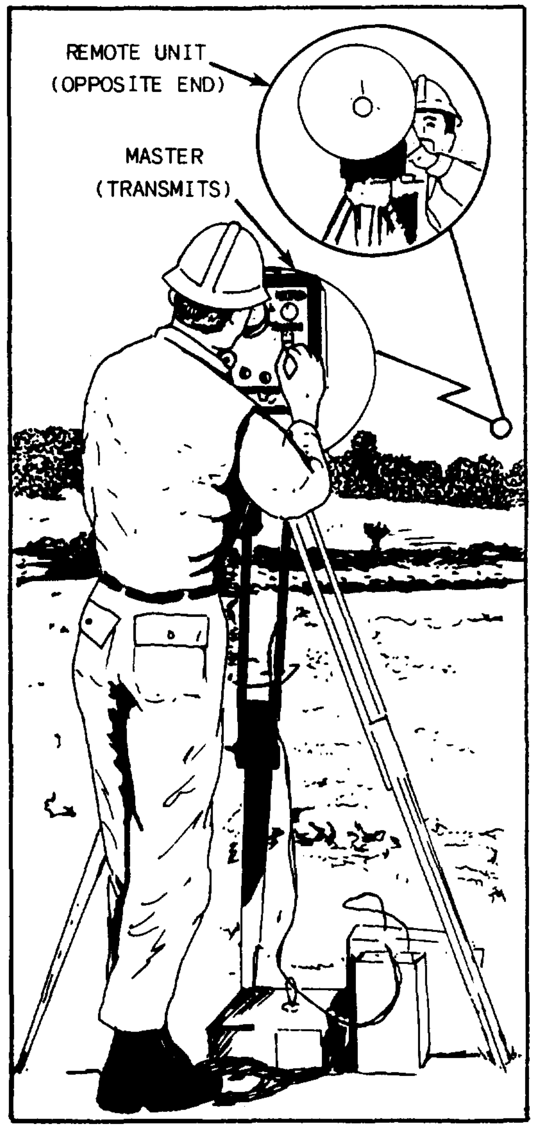

Figure 12-24.-Setting a microwave distance-measuring unit.

Measuring by Microwave Devices

The microwave distance-measuring device (fig. 12-23) is an electronic instrument that transmits precisely controlled RADIO WAVES between two units. The waves are compared and electronically changed into a visually readable form from which the distance between the units can be computed.

As shown in figure 12-24, the unit that originates and transmits the modulated radio waves is called the master. The unit at the opposite end of the line from the master is known as the remote. The two are identical instruments, each being adaptable to use as either master or remote. At the remote unit, the original transmission is received, interpreted, and put on a new carrier. This new modulation is amplified and retransmitted to the master. The master analyzes the new transmission and translates it into a trace on a cathode ray tube that can be read visually. The trace information is converted into a distance based on the velocity of the radio waves. Because this velocity is affected by atmospheric conditions, corrections for temperature and barometric pressure are applied according to instructions.

Each instrument is equipped with a shortwave telephone set. By this means, the person at each instrument can maintain communication with the other. <u>Details of the method of operating the system must be learned from the manufacturer's instructions.</u>

Measuring by Light Wave Devices

The light wave measuring device (fig. 12-25) uses electro-optical instruments to measure distances accurately. The device consists basically of two units: the measuring unit (transmitter/receiver) and the reflector unit (fig. 12-26). The distance is measured by precise electronic timing of a modulated LIGHT WAVE after it travels to, and when it returns from, a reflector at the other end of a course (fig. 12-27). When the instrument receives the reflected light flash, it registers readings that can be converted into the linear distance between the instrument and the reflector (with corrections made for atmospheric conditions).

Like their microwave counterparts, the light wave distance-measuring devices are capable of first order base lines in triangulation and all orders of traverse distance measurements. Most of these instruments have a rated range of 200 to 50,000 meters.

These instruments, as all delicate scientific equipment, are to be treated with proper care and operator maintenance so that they may continue to be available for use. Refer to the instrument manufacturer's manual for instructions on basic operation, care, adjustments, calibrations, and other details of the system.

FIELD PARTY SAFETY

A surveying field party is frequently working its way through rugged terrain a long distance away from any professional medical assistance. Working through brush, felling trees, scaling bluffs, and crossing streams are all hazardous. Also, the use of such sharp-edged tools as machetes, brush hooks, axes, and hatchets is equally hazardous. Besides those dangers that are inherent in the work itself, a party may be exposed to a variety of natural dangers, such as those created by weather conditions, by reptiles, by insects, and by poisonous plants. Occasionally, in some areas, there may be dangerous wild animals or even dangerous domestic animals, such as vicious dogs or angry bulls. When a party is working along a thoroughfare on which vehicular

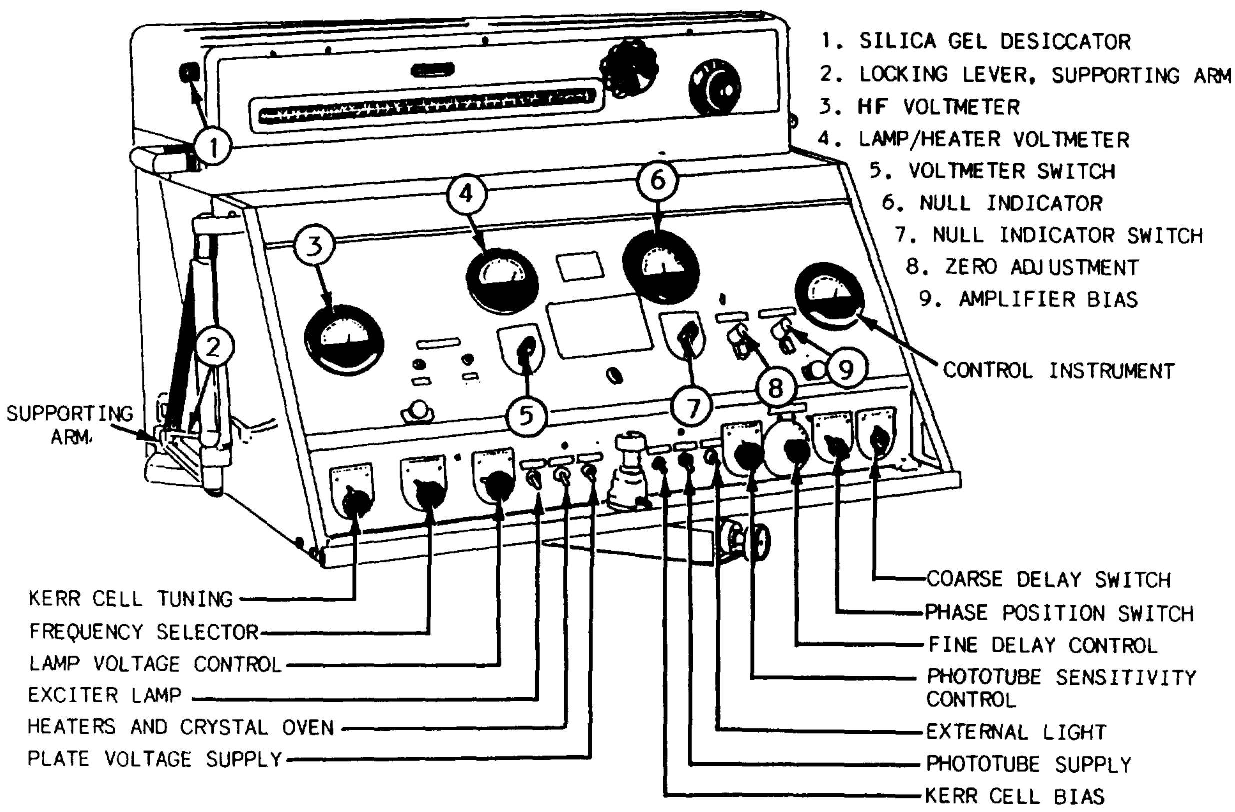

Figure 12-25.-A light wave distance-measuring device (Geodimeter, Model 2A).

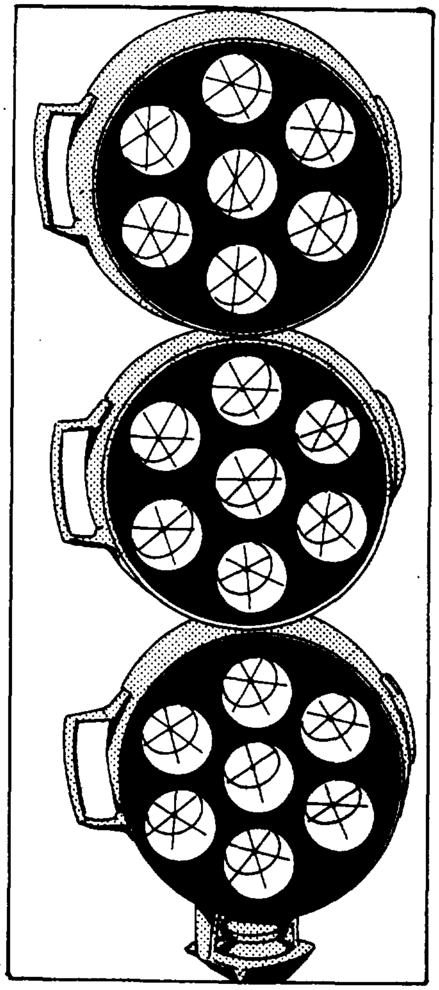

Figure 12-26.-Light wave reflector units, stacked.

traffic is proceeding as usual, there is the ever-present idanger of being hit by a vehicle.

In the midst of such a variety of constant dangers, the only way to prevent injury is by the exercise of continual care and vigilance. Every person in a party must be aware of all existing hazards, be able to recognize a hazardous situation, and be trained to take the correct preventive measures.

Indeed, it is common practice for surveying field crews to prepare a CHECKLIST of essential items, personal protective equipment, communication gear, and other miscellaneous items relative to their line of work.

ADMINISTERING FIRST AID

If personal injuries do occur, it is essential that the injuries be taken care of to the extent possible by the application of first aid. The *Standard First Aid Training Course,* NAVEDTRA 10081 (latest revision), defines first aid as "the emergency care given sick or injured persons until regular medical or surgical aid can be obtained." Your principal source of information on first aid is the *Standard First Aid Training Course.*

Every person in a field party should be able to administer first aid, regardless of how junior in rate and experience each person may be. A chaining party may consist of only two persons, one of whom may be very junior in rate and time in service. Since the party chief may be the one injured, the junior member of the party would be responsible for administering first aid.

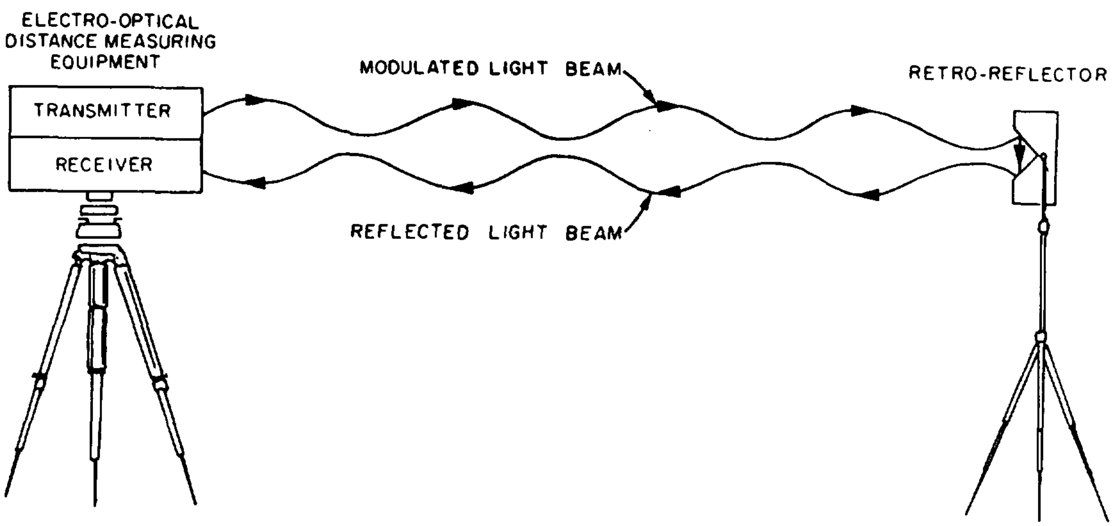

Figure 12-27.-Typical configuration of a light wave distance-measuring device.

As a rule, field crew members should be familiar with the telephone number and location of the nearest hospital or dispensary their party will be operating, should have a transport vehicle available and ready, and should have valid government vehicle operator's licenses. In addition, a first-aid kit should be kept handy at all times.

PROTECTING AGAINST WEATHER HAZARDS

For all weather hazards, the best preventive measure is the wearing of adequate protective clothing. When the weather is cold enough to cause frostbite, wear a hat that covers your ears, gloves or mittens for your hands, and cold-weather footgear for your feet. These are the primary areas most subject to frostbite. Wear a hat also when there is danger of heatstroke. Unless or until you are immune to sunburn (by tanning), keep your skin covered against the sun. Fair-haired or sandy-haired individuals, even when they tan, may be susceptible to a form of skin cancer caused by exposure to sunlight. If you are in this category, you should keep the skin covered whether you "tan" or not.

Two very common weather hazards, frostbite and heatstroke (commonly called sunstroke), are fully covered in the *Standard First Aid Training Course.* Lesser weather hazards, such as the exposure caused by wearing insufficient clothing in cold or wet weather and the possibility of a bad sunburn in hot weather, are not mentioned.

In general, when you set forth with a field party, wear or carry with you clothing that will provide adequate protection against the weather—not just as it is at the time you set forth, but as it may possibly develop before you get back.

RECOGNIZING AND AVOIDING POISONOUS REPTILES AND INSECTS

As a general rule, it is best to assume that all reptiles of the snake family found in the United States and overseas and that all insects you can't recognize as poisonous MAY BE poisonous.

The poisonous snakes of the North American continent belong to the viper family. The distinguishing characteristics of a viper area flat head and a thick body. The most common North American viper is the RATTLESNAKE. All rattlesnakes are distinguishable by a row of hard rings, called rattles, on the tail. The snake makes a hissing sound with them when it is angry or alarmed. The banded, or timber, rattler of the northeastern United States is smooth, silver gray in color. The diamondback rattler of the United States Deep South is silver gray with a diamond-shaped pattern on the skin. The western diamond-back rattler has the same diamond pattern, but is a copper color. The red rattler of southern California is a deeper copper color.

Besides the rattlesnake, the most common North American poisonous snake is the WATER MOCCASIN, sometimes called the cottonmouth because of a white mouth lining that the snake exposes when preparing to strike. The skin of the water moccasin is dark brown with black bars on the upper side and black blotched with yellowish white on the under side.

The reddish brown COPPERHEAD has no rattles. This viper is found especially in uplands of the eastern Unites States.

The most common poisonous insects encountered in North America are the BLACK WIDOW SPIDER, the TARANTULA, and the SCORPION. The black widow (which may be encountered anywhere in the United States) is recognizable by its small, shiny black body. The tarantula is a long-legged, hairy member of the spider family, found chiefly in and close to Texas. The scorpion, found mainly in the semitropical parts of the United States, resembles a lobster or crawfish in shape.

The symptoms that develop from the bite of each of the reptiles and insects mentioned, together with the appropriate first aid, are thoroughly described in the *Standard First Aid Training Course,* NAVEDTRA 10081 (latest edition).

AVOIDING OR TREATING POISONING FROM POISONOUS PLANTS

The *Standard First Aid Training Course* contains an extensive section on a variety of poisons. However, it does not mention a type of poisoning to which survey parties are particularly exposed—poisoning resulting from contact with poisonous plants. Poisoning of this kind is not likely to be fatal (although it can be, under certain circumstances), but it can cause you a lot of misery and considerable reduction in on-the-job efficiency.

The most common poisonous plants in the United States are POISON IVY (including a variety called poison oak) and POISON SUMAC, both of which occur everywhere in North America. These plants contain and exude a resinous juice that produces a severe reaction when it comes into contact with the skin of the average person. The first symptom of itching or a burning sensation may develop in a few hours or even after 5 days or more. The delay in the development of symptoms is often confusing when an attempt is made to determine the time or location where the contact with the plant occurred. The itching sensation and subsequent inflammation that usually develops into watery blisters under the skin may continue for several days from a single contamination. Persistence of symptoms over a long period is most likely caused by new contacts with plants or by contact with previously contaminated clothing or animals.

Severe infection may produce more serious symptoms that result in much pain through abscesses, enlarged glands, fever, or other complications. Secondary infections are always a possibility in any break in the skin that occurs when the watery blisters break.

With poison ivy, the next development is usually the appearance of a scabrous, deep red rash over large skin areas. With poison, sumac, it is usually the appearance of large blisters, filled with a thick yellowish white liquid strongly resembling pus. When the blisters break, this liquid runs over adjacent skin areas and, thus, enlarges the area of infection.

The resinous juice exuded by these poisonous plants is almost entirely nonvolatile; that is, nonevaporating or will not dry up. Consequently, the juice may be carried on clothing, shoes, tools, or soil for long periods. In this way, it may infect persons who have actually not come into contact with the plants themselves. Individuals have, in fact, been severely infected by juice carried through air by smoke from burning plants. Other persons have been infected by resinous juice being carried on the fur of animals.

Figure 12-29.-Poison oak (leaves and fruit).

To avoid contact with the plants themselves, you must have an idea of what they look like. Poison ivy has a trefoil (three leaflet) leaf, as shown in figure 12-28. The upper surface of the leaflet has a shiny, varnished appearance. The variety called poison oak has a leaflet with a serrated, or lobed, edge like that of an oak leaf, as shown in figure 12-29. Ordinary poison ivy is

Figure 12-28.-Different varieties of poison ivy leaves.

usually a vine; poison oak, usually a bush. In the flowering season, both types produce clusters of small white berries.

Different varieties of poisonous sumac leaves are shown in figure 12-30. There are poisonous sumacs and harmless sumacs, and it is difficult to distinguish the leaf of one from the leaf of the other. The only way to tell the poisonous plant from the harmless one is by the fruit. Both plants produce a drooping fruit cluster. The difference lies in the color of their fruits—that of the harmless sumac is RED; that of the poison sumac is WHITE. In other than the fruit season, it would be better to avoid contact with all sumacs.

There are no "do-it-yourself" remedies for plant poisoning; treatment must be by, or as directed by, professional medical personnel. However, if you have reason to believe that you have been infected, you should wash thoroughly with water and an alkaline laundry soap. Do not use an oily soap (most facial soaps are oily) because this will tend to spread the juice. Lather profusely, and do not rinse the lather off, but allow it to dry on the skin. Repeat this procedure every 3 to 4 hours, allowing the lather to dry each time.

If job conditions make contact with plants unavoidable, wear gloves and long sleeve shirts and keep all other skin areas covered. When you remove your clothing, take care not to allow any skin area to come into contact with exposed clothing. Launder all clothing at once.

USING FIELD EQUIPMENT SAFELY

The standard source of information on the safe use of dangerous field equipment and other safety precautions is *Safety Precautions for Shore Activities*, NAVMAT P-5100. A copy of this publication should be available in your technical library.

Since tools are a potential source of danger in all occupations, they should be inspected periodically to find out whether any repairs or replacements are needed. Only tools in good condition should be used. There should be no loose heads on any hand tools. Sharp-edged tools should be kept sharp. All tools should be stored safely when not being used.

If tools with sharp blades or points are laid down on the job temporarily, they should be placed in such a way that no injury can result to anyone. Sheaths or guards are desirable when sharp-edged or pointed tools are being carried from one place to another. If sheaths are not available, carry a tool with the sharp edge or point

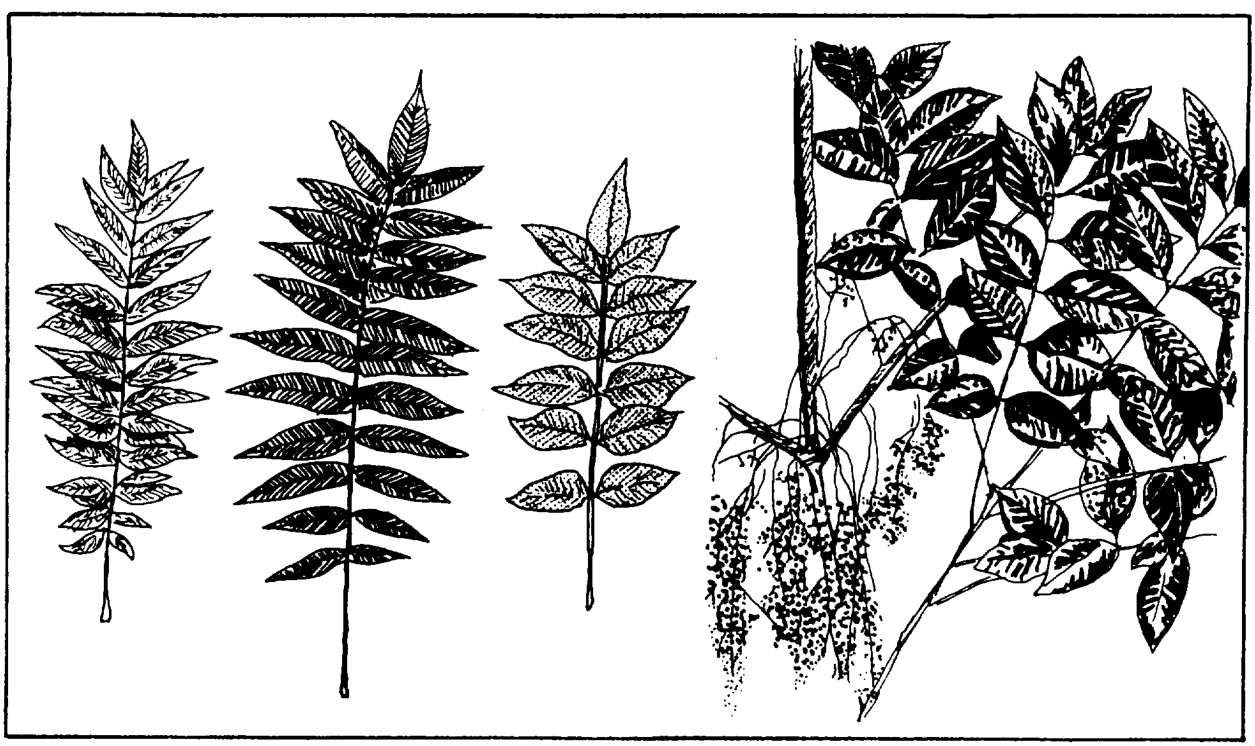

Figure 12-30.-Varieties of sumac leaves.

away from your body and take care that you do not injure others with it.

When working near other people, carry your range poles or level rods vertically against your body so that another person's head or eyes will not be injured if you turn suddenly. Do not hold a stake or bull-point with your hand around the shank while another person is driving it with a sledgehammer. Do not let a tape or plumb bob cord slide fast through your hands.

Always use tools correctly and for the purpose for which they are intended. For example, when cutting brush near the ground with a machete, swing it away from your legs and feet. Never cut at short range from your body. Be sure that the radius of your swing is clear of obstructions, such as vines or twigs, that might deflect the intended direction of the swing. Use your full arm's length to get a safe-swing radius. Always work at least 10 ft away from the nearest person. If it is necessary to use an ax to clear an area, you can prevent painful blisters by wearing a pair of thin gloves. Above all, use common sense and consider the possible results of your actions.

To climb poles and trees safely, it is best to use authorized climbing equipment. A lineman's pole climbers are made of steel and have a strap loop and short spur. Tree climbers have straps, pads for protection against friction, and a longer spur for penetrating bark. To avoid falling, use both belt and straps. Except in an emergency, never work in or on trees during a high wind. Watch out for power lines that may be in contact with the tree you are climbing.

Burning operations should always be conducted in the clear, where the fire will not ignite tree leaves or limbs, dry wooded areas, or nearby buildings. Remember that it is imperative that all burning or smoldering material be completely extinguished before it is left unattended.

When practicable, use only nonflammable solvents for cleaning instruments. Do not leave the caps off or the stoppers out of flammable liquid containers. Use solvents only in a well-ventilated location.

All of the above could be boiled down to this: **ALWAYS USE GOOD JUDGMENT AND COMMON SENSE.**

FOLLOWING SAFETY PROCEDURES IN TRAFFIC

A party working on a highway where vehicular traffic is proceeding is in great danger of being struck. Every motion made by a member of such a party must be made with a continuing, full awareness that vehicular traffic is, in fact, proceeding as usual. The dangers of the situation should be minimized as much as possible by the following measures as well as by others that some situations may require.

Work should be scheduled as much as possible to take place during those hours when traffic is slack. Work during "rush hour" on a metropolitan highway, for instance, could be so dangerous as not to be a practical endeavor.

Adequate traffic warning signs, such as "Men Working," "Drive Slowly," "Single Lane Ahead," and the like, should be placed where they will be most effective in warning drivers and, if possible, in detouring traffic away from the field party. If detouring requires two-way traffic on a single lane, a flagman has to be posted at each end of the lane.

Signs, barriers, and equipment in use, such as instruments, targets, and the like, should be made as conspicuous as possible by the attachment of bright-colored bunting. Personnel should also make themselves as conspicuous as possible by wearing orange-colored shirts, vests, or jackets.

One last word of advice may seem inconsistent with your standards about what constitutes proper performance of duty. Suppose you are functioning as an instrumentman with a party on a highway, and you suddenly observe that a car out of control is bearing down on the instrument at high speed. You will have a strong impulse to attempt to rescue the instrument. Do NOT do this if it could result in death or injury to yourself.

ADDITIONAL DUTIES OF A SURVEY CREW

Other tasks that you might perform as a survey crew member include the maintenance of various surveying equipment and accessories, preparation of the field party's essential needs, field sanitation, and the conducting of prestart checks and operator's maintenance of government survey vehicles.

MAINTAINING SURVEYING EQUIPMENT

Generally, the maintenance of surveying equipment and accessories involves proper cleaning and stowage. For example, steel tapes, brush hooks, axes, chain saws, and so forth, must be cleaned and dried and, if necessary, a thin coat of oil applied after each day's work before they are stored for the night. Never stow any surveying gear (especially if made of ferrous material) without checking it thoroughly to make sure it is clean and dry—particularly steel tapes. The reason for this is that, in the SEABEEs, we have a multitude of jobs done under variable conditions. Suppose that today you are sent to a job that does not require the same equipment you used yesterday and failed to clean. You are kept on this job for a few days. There is a good chance that the equipment you used the first day will be rusty when you return to use it again.

Remember that you are liable for payment for any loss of government property caused by your own negligence.

You will be required to sharpen surveying clearing tools, replace any broken handles, especially those on sledgehammers, and do many other things. For delicate equipment, consult the manufacturer's handbook or other applicable publications before you attempt any servicing or cleaning, and, if necessary, ask your senior EA to explain the correct procedure to follow.

PREPARING FOR FIELD PARTY'S ESSENTIAL NEEDS

You need to know how to prepare or gather your various needs for the day; for example, stakes, hubs, markers, safety gear, drinking water, and food. The preparation of the list of these things is the responsibility of your party chief; however, everyone in the survey party should review the list to make sure that everything needed for that particular job is there. Remember that you are concerned with the necessary equipment not only for the job, but also for your personal needs, especially if the job is quite a distance from your base camp.

In a triangulation survey, for example, your stations are generally situated in remote places. You may be ferried to your station point by helicopter or by some other means, depending on the location and the mode of transportation available. Be sure to take extra drinking water to jobs like this, and DO NOT discard your excess water until you are safely back to your base camp.

MAINTAINING FIELD SANITATION

In the field, devices necessary for maintaining personal hygiene and field sanitation must be improvised. If you are surveying at a remote location, it is unlikely that you will find a waterborne sewage system available for your use. The usual alternative is digging a "cat hole" about 1 ft deep and covering the feces completely with dirt.

Proper disposal of garbage should also be undertaken during field surveys. Whenever possible, avoid burning dry garbage on site. Disposal bags offer a good means of preventing litter and should be used whenever available.

In extremely hot climates, your supply of potable water is expected to run low at a faster rate. To avoid dehydration, you will be required to treat your own water or face infections or diseases, such as dysentery, cholera, diarrhea, and typhoid fever. It is imperative that water taken from any source (such as lakes, rivers, streams, and ponds) be properly treated before being used, as all these sources are presumed to be contaminated. To treat water for drinking, you can use either a plastic or aluminum canteen with the water purification compounds available in tablet form (iodine) or in ampule form (calcium hypochlorite). When disinfecting compounds are not available, boiling the water is another method for killing disease-producing organisms. The standard source of information for SEABEEs on field sanitation and personal hygiene is *Seabee Combat Handbook,* NAVEDTRA 10479-C2, chapter 8.

GIVING VEHICLE PRESTART CHECKS AND MAINTAINING VEHICLE OPERATIONS

It is likely that the field survey crew will be assigned a vehicle to transport people and equipment to and from the jobsite. Before operating the vehicle, the operator is to give it a prestart check to make sure that it is ready to run.

When a vehicle is assigned to you, an operator's daily preservice maintenance report is issued at the dispatch office. Use this form to record or log items in the vehicle requiring attention as observed during the prestart check and during the working day. Other information, such as mileage readings, operating hours, and fuel consumption may also be required.

A complete checklist of the vehicle prestart and operator's maintenance procedures are described in *Equipment Operator 3 & 2,* NAVEDTRA 10640-J1, chapters 2 and 4.